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WILCOM/T195

**MODEL T195
LEVEL TRACER**

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MODEL T195 LEVEL TRACER

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If faulty conditions develop, notify WILCOM for instructions. Servicing information will be supplied wherever possible. If the equipment is to be returned for repairs, please include a description of the faulty condition and who should be contacted if additional information is needed. Ship the equipment prepaid.

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**MODEL T195
LEVEL TRACER**

SERVICE MANUAL

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1.0 GENERAL

1.1 Description

1.1.01 This manual describes the Wilcom Model T195 Level Tracer. The Level Tracer is a full send/receive instrument capable of measuring multiple telephone line parameters and displaying the parameters as continuous functions of frequency over all, or a selected portion, of the 20 to 20,000 Hz frequency band.

1.1.02 Two independent traces of measured transmission level, return loss, or impedance parameters can be presented simultaneously on the T195's CRT display screen. Either or both of the traces can display present measurement results, or past measurements results, read from storage in the T195's digital memory.

1.1.03 Thus, the T195 is capable of measuring and displaying:

- (1) the characteristics of two individual telephone lines;
- (2) the characteristics of a single telephone line before and after changes such as loading, build-out, conditioning, gain correction, or any other adjustment . . . the effects of such changes can be observed in seconds;
- (3) the characteristics of a single telephone line versus the characteristics of a comparison standard;

(4) the characteristics of a single line's T and R leads to ground.

1.1.04 Because of these capabilities and other new concepts in level tracer design, the T195 makes testing faster and easier in maintenance, engineering, and cable acceptance work. It makes available various new measurement and analytical techniques not possible with instruments of previous design. Its special features and capabilities are briefly described in the following paragraphs.

1.2 Features and Capabilities

1.2.01 Each measurement made by the T195 is digitized and stored in solid state memory from which the displayed traces are derived. Either or both of the traces can be updated with new measurement data continuously or periodically as desired. Data from a measurement can be retained indefinitely in the memory for either trace, permitting a user to hold past measurement traces on the screen as long as needed. The traces are displayed with constant brightness regardless of how long they are held on the screen.

1.2.02 The CRT screen has a calibrated graticule (like an oscilloscope) from which level, return loss, and impedance values can be read directly over the frequency range covered by a measurement. Positioning controls allow the traces to be superimposed or separated as needed to match and compare their variations.

1.2.03 For some tests, the instrument can be manually tuned to acquire measurement data at specific frequencies.

Or, it can be set to automatically sweep across any of four frequency ranges . . . from 20 Hz on the low end to 400, 4000, 8000, or 20,000 Hz on the high end.

1.2.04 For transmission level measurements, the T195 can also be set to automatically seek, lock on, and then track the frequency of a test signal incoming from an external source. Lock on and tracking are fully automatic regardless of whether the external source is a swept frequency generator, a manually-tuned test set/oscillator, or a fixed frequency unit such as a regular office milliwatt test line.

1.2.05 In all cases, test frequency is displayed on a front panel digital readout with an accuracy of ± 1 Hz. Smaller marker "pips" can also be switched on to indicate test frequency on the displayed CRT traces.

1.2.06 In level test mode, the T195's measure/display section can handle an extremely wide input level range . . . from +20 to -89 dBm. Using a swept frequency test signal and appropriate control settings, the CRT trace will show the frequency response curve of a circuit under test with such fidelity that level variations as small as ± 0.2 dB can be clearly seen.

1.2.07 The level measurement input configuration is pushbutton selectable for terminating or bridging connections on circuits of 150, 600, and 900 ohms impedance. Internal calibration is automatically controlled such that the CRT reads correctly in dBm for the circuit impedance selected.

1.2.08 The T195's precision internal oscillator can be used in level measurements as a send section (source) of manually-tuned or swept frequency signal for transmission into a circuit under test. Send impedances of 150, 600, and 900 ohms are selectable.

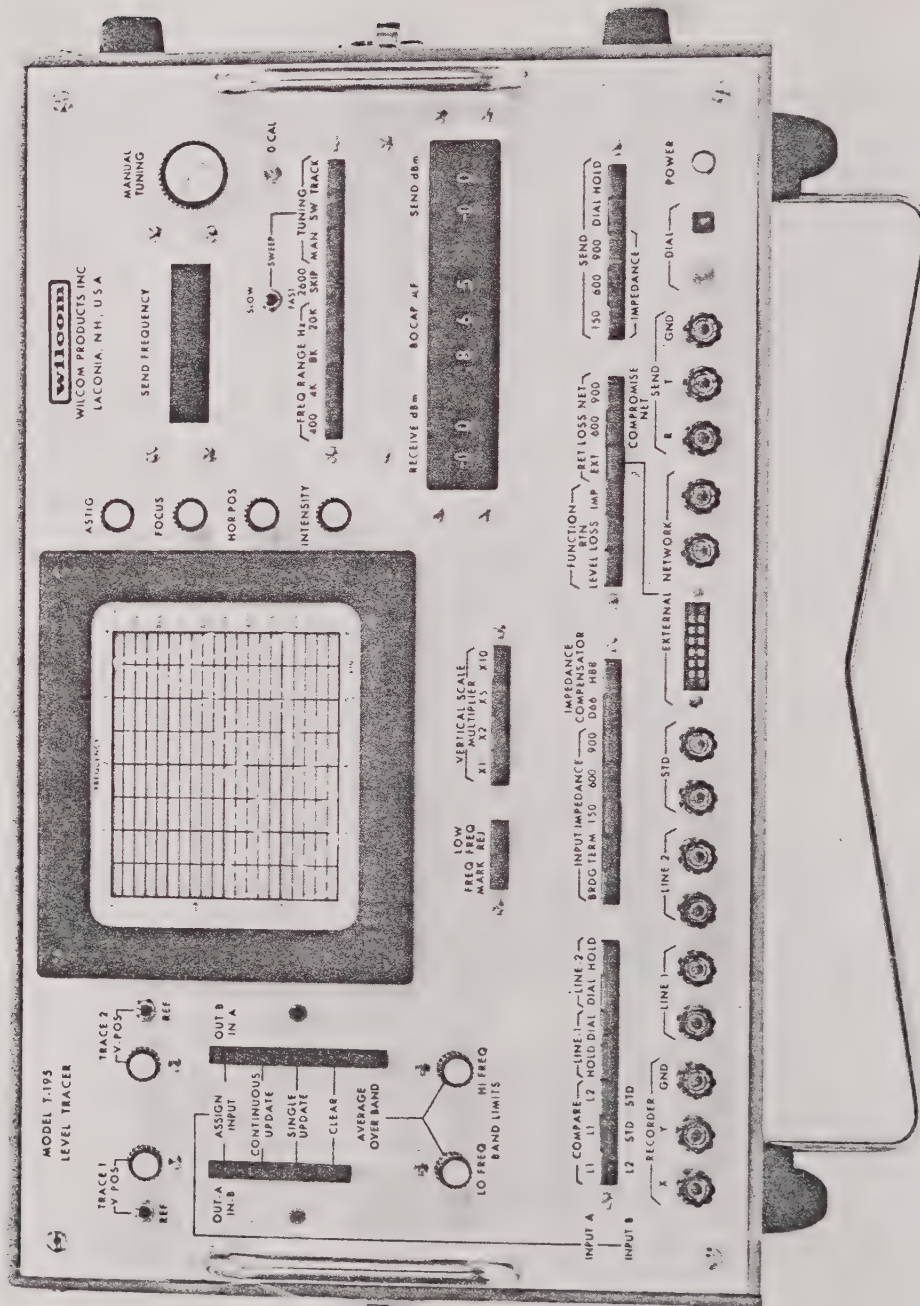
1.2.09 The oscillator's output signal is automatically leveled to maintain amplitude constant within ± 0.2 dB over the entire tuning range. Thumbwheel switches allow the output to be set anywhere between +19 and -49 dBm in 1-dB steps. As required, a user may instruct the T195 to cut off the transmitted signal automatically any time tuning enters a 300 Hz band centered at 2600 Hz.

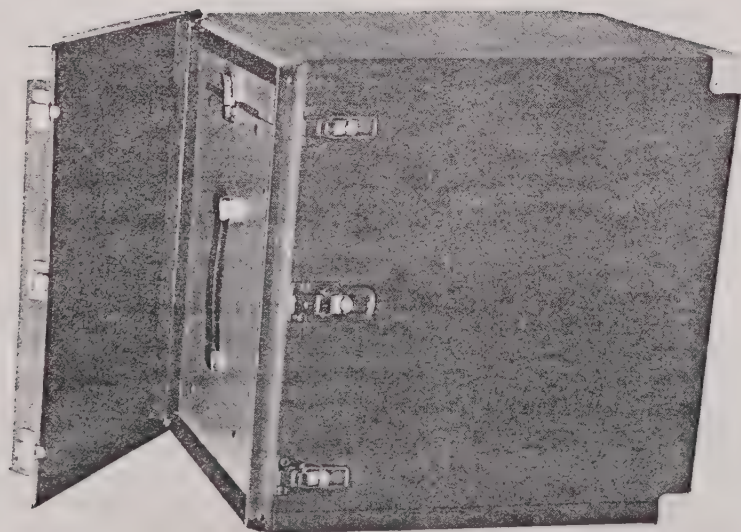
1.2.10 Both send and receive portions of the T195 are equipped with dial and hold provisions to permit convenient, one-man level measurements through a loop-around test line. In such uses the T195 sends into one leg of the loop while simultaneously measuring and displaying the signal received from the loop's other leg.

1.2.11 In return loss mode, the T195 makes manually-tuned or swept frequency measurements over a 0 to 45 dB return loss range. The following provisions are built-into the T195 for return loss measurements:

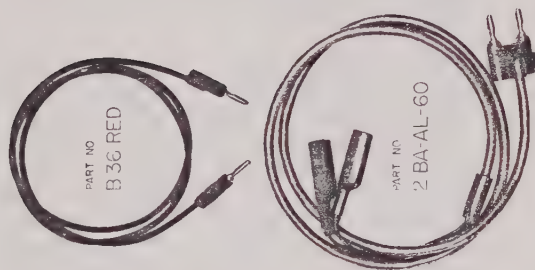
(1) precision hybrid;

(2) thumbwheel-selectable build-out capacitance covering 0.001 to 0.999 μ F in 0.001 μ F steps with accuracy of ± 1 percent;

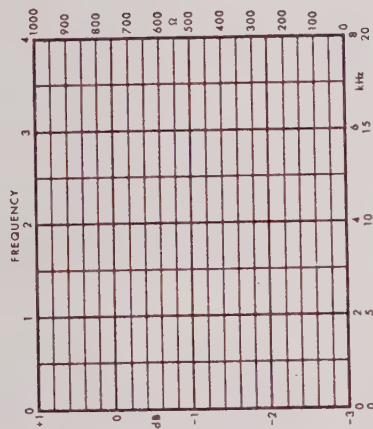
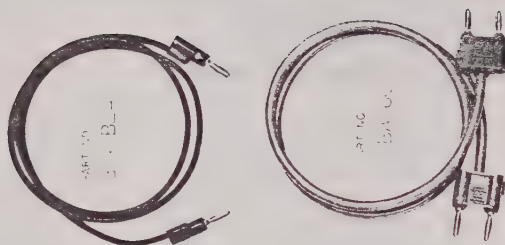




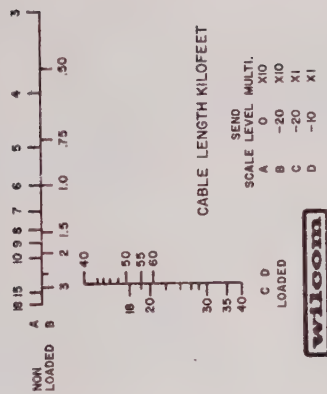
Carrying Case



Patch Cords



Graticules



Loop Length

FIGURE I-2
Accessory Equipment

(3) switch-selectable impedance compensators for H88 and D66 loaded cable;

(4) switch selectable compromise network of 600 or 900 ohms in series with 2.16 uF;

(5) panel connections for an external precision network.

1.2.12 In impedance mode, the T195 makes manually-tuned or swept frequency measurements of impedances between 0 and 10,000 ohms. Accuracy and resolution of the swept frequency impedance display is such that characteristic variations of cables having up to 20 load points can be clearly seen. Even the effect of a missing 19th load coil becomes immediately visible when a trace of that cable is superimposed over the trace of a normal 20 load point cable.

1.2.13 The impedance mode may also be used to find the capacitance or resistance of loaded or non-loaded cable. This permits determination of cable length and the distance to shorts or opens. (With an artificial line, the locations of bridged taps can also be determined.)

1.2.14 An internal measurement integration feature can be switch-selected in either impedance or return loss mode. This feature causes the CRT display to show impedance or return loss as an average value between high and low frequency limits set by the user. The average is displayed as a straight, horizontal line on the screen between the two frequency limits.

1.2.15 Both echo return loss and singing return loss can be conveniently measured using the averaging feature. And, this feature greatly facilitates building-out a precision network with capacitance until the best return loss value is obtained. The effects of build-out capacitance changes as small as 0.001 uF can be easily observed.

1.3 Accessory Equipment

1.3.01 Four patch cords are available for connections to circuits under test. They are described in Table I-1.

TYPE	DESCRIPTION
2BA-60	5 feet long, twin banana plug at each end
2BA-AL-60	5 feet long, twin banana plug at one end and two alligator clips at the other end
B36 RED	3 feet long, single conductor with a banana plug at each end
B36 BLACK	3 feet long, single conductor with a banana plug at each end

1.3.02 The T195G0 graticule overlay is available which may be mounted on the front of the T195 Level Tracer. The overlay permits the recording of the impedance, return loss on level characteristics with a felt tip pen. These data may be reproduced on a copy machine for a permanent record and the graticules wiped clean for re-use.

1.3.03 A loop Length Measuring Graticule is also available and may be mounted on the front of the T195

Level Tracer. This graticule allows direct measurement of loop length of loaded or non-loaded cable facilities.

1.3.04 A fiber board carrying case, Model T195CC, is available to provide additional protection for the T195 during transportation.

1.4 Related Equipment

1.4.01 Two companion equipment items are particularly useful in various tests using the T195 Level Tracer. The Wilcom Model T205 Sweep Generator is an ideal source of swept frequency level test signals for use at the distant end of a circuit being examined by the T195. The Wilcom Model T240 Artificial Cable Kit is a flexible, accurate comparison/simulation standard particularly helpful in diagnosing various cable faults. These items are briefly described in the following paragraphs.

1.4.02 Model T205 Sweep Generator - The Model T205 Sweep Generator's characteristics and capabilities are very similar to those of the T195's internal sweep oscillator. The T205 Sweep Generator produces a manually-tuned or automatically swept frequency output in four selectable ranges up to 20,000 Hz. Output level is adjustable in 1 dB steps from +9 to -49 dBm. Two separate outputs are provided so two individual circuits can be tested simultaneously without interference between the two.

1.4.03 Model T240 Artificial Cable Kit - The Model T240 Artificial Cable Kit contains line-section modules which closely represent actual telephone cable sections. The kit has facilities which can be used in conjunction with the T195 Level Tracer to simplify and expedite analysis of numerous cable fault conditions.

1.4.04 With the kit, simulated cable fault conditions can be introduced and removed via switches, without need to physically disconnect modules from the artificial line and then reassemble the line. The kit makes it easy to set up for analyzing the effects of:

- (1) split pairs,
- (2) bridged taps,
- (3) unbalanced grounded ringers,
- (4) high series resistance unbalance,
- (5) shunt capacitance unbalance,
- (6) missing or improperly connected load coils,
- (7) multiple ringers bridged on a loop,
- (8) and other cable conditions.

The kit has appropriate precision and compromise networks for return loss and impedance measurements.

1.4.05 Recording Patterns by Camera

(1) A polaroid camera with a close-up lens and mounted on a tripod or a solid table surface will provide usable photographs. The camera should be placed so the lens is about 10" from the graticule and then focused. The brightness of the trace can be adjusted with the

control. Incident light does not hurt the picture. Bright sunlight should be avoided and a filter should be used.

The Electronix C-5A Camera may be held against the bezel during exposure to provide support without external support or ambient light. The camera should be held against the bezel to avoid the graticule lines, caused by the camera being visible on the CRT.

1.5 Factory Options

1.5.01 Variable Sweep Speed - The Level Tracer may be ordered with a continuously variable knob control to replace the SLOW/FAST toggle switch. The control allows sweep speed to be adjusted from approximately 1.5 seconds to 25 seconds.

SPECIFICATIONS

2.1 Send Section

2.1.01 Frequency:

Range: 20 Hz to 20 kHz in four bands as follows:

- 20 to 400 Hz
- 20 to 4000 Hz
- 20 to 8000 Hz
- 20 to 20,000 Hz

Tuning:

SWP: Automatic linear frequency sweep through selected range.

Sweep Rate: Slow (approximately 5 seconds for full sweep) or Fast (approximately 1-1/2 seconds).

MAN: Manual tuning through selected range.

TRACK: Locks to and follows received frequency.

DISPLAY: Digital readout to nearest 1 Hz.

Marker: Switch selectable. A short vertical line on each display trace indicating the present Send Frequency.

SF SKIP: Switch selectable. Send output is switched off when generator frequency is in a 300 Hz band centered at 700 Hz.

2.1.02 Level:

Range: +19 to -49 dBm

Control: Thumbwheel switches, one dB steps

Accuracy at 1 kHz: ± 0.2 dB, at any control setting and all operating conditions within ratings.

Accuracy vs frequency: +0.2 dB, 100 Hz to 20 kHz for 600 ohms or 900 ohms SEND IMPEDANCE; 500 Hz to 20 kHz for 150 ohms. (At lower frequencies, terminated Send Level accuracy is limited by loss in dc blocking capacitors.)

2.1.03 Output Impedance: Selectable 150, 600 or 900 ohms $\pm 1\%$, balanced and dc blocked for 300 volts.

2.1.04 Distortion: Total harmonic distortion more than 60 dB below fundamental frequency level ($f \cdot 100$ Hz)

2.1.05 Noise: -70 dBm (0-20 kHz BW)

2.2 Receive Section

2.2.01 Functions: Level, Return Loss, Impedance.

2.2.02 Ranges:

LEVEL:

At 0 dB on graticule: -59 dBm to +19 dBm.

Including readable graticule range with X10 multiplier: -89 dBm to +20 dBm

RET LOSS: 0 to 45 dB

IMP: 0 to 10,000 ohms.

2.2.03 Level and Return Loss Attenuator:

Thumbwheel switches designated RECEIVE dBm, set zero level on graticule in 1 dB steps.

2.2.04 Accuracy (at 1 kHz):

LEVEL & RETURN LOSS:

At zero reference on graticule: ± 0.2 dB for any attenuator switch setting and all operating conditions within ratings.

Scale deflection: $\pm 3\%$ of reading

IMPEDANCE:

100 ohms to 1 k ohms:

$\pm (1\% \text{ of scale} + 3\% \text{ of reading.})$

Below 100 ohms:

Above 1 k ohms: Additional error caused by 100 k ohms shunt across impedance being measured.

2.2.05 Frequency Response (referred to 1 kHz):

LEVEL:

BRDG: ± 0.2 dB, 20 Hz to 20 kHz

TERM:

600 or 900 ohms: ± 0.2 dB, 200 Hz to 20 kHz

150 ohms: ± 0.2 dB, 500 Hz to 20 kHz

RET LOSS: ± 0.2 dB, 20 Hz to 20 kHz

IMP: $\pm 2\%$, 20 Hz to 20 kHz

2.2.06 Input Impedance:

LEVEL: Switch selectable 150, 600, or 900 ohms TERM or approximately 100,000 ohms BRDG, balanced and dc blocked for 300 volts.

RET LOSS: Equals network impedance.

IMP: Approximately 100,000 ohms.

2.2.07 Longitudinal Balance: Greater than 80 dB up to 4 kHz.

2.2.08 Input Noise (no signal):

Less than -85 dBm when terminated.

2.2.09 Tracking: In LEVEL function, the send generator will track a receive frequency with receive level between 10 dB above and 30 dB below the zero reference on graticule. (-89 dBm to +20 dBm limits.)

2.2.10 AVERAGE OVER BAND: Switch selectable. When this function is selected, the stored data for trace 2, over a selected frequency band, is averaged as it is dis-

played and appears as a horizontal line at the average value between the selected frequency limits.

IMPED: Linear average of impedance over selected band.

LEVEL or RET LOSS: Quasi power average, or a non-linear average of the stored dB level over the selected band, designed to approximate a true power average expressed in dB.

2.2.11 Miscellaneous Receive Features:

LOW FREQ REJ: Switch selectable,

- 60 Hz: down down greater than 60 dB
- 180 Hz: down approximately 15 dB
- 300 Hz: down less than 3 dB

RET LOSS NET: Switch selectable:

EXT: Socket for Wilcom precision net, in parallel with binding posts.

600 COMPROMISE NET: 600 ohms $\pm 1\%$ in series with 2.15 μF .

900 COMPROMISE NET: 900 ohms $\pm 1\%$ in series with 2.16 μF .

IMPEDANCE COMPENSATOR: Switch selectable. Inductor inserted in series with line for impedance compensation:

- H88: 44 mH
- D66: 33 mH

B.O. CAP: Build out decade capacitor settable by 3-decade thumbwheel switches, to .999 μF in .001 μF increments. Overall tolerance $\pm 1\%$. The B.O. Cap is connected across the line if either H88 or D66 compensation is selected. It is connected across the EXT NET terminals if neither impedance compensation is selected.

2.3 Display

2.3.01 Trace: Dual trace with separate storage for each trace, and continuous presentation of stored data.

2.3.02 Viewing area: 80 x 95 mm.

2.3.03 Graticule: Vertical - linear dB and ohms; horizontal - frequency.

2.3.04 Vertical Scales:

Multiplier: 1X, 2X, 5X, 10X.

dB Scale: 0.2, 0.4, 1 and 2 dB divisions depending on vertical scale multiplier.

Impedance Scale: 50, 100, 250, and 500 ohm divisions depending on vertical scale multiplier.

2.3.05 Horizontal Frequency Scale: 50, 500, 1000 and 2500 Hertz divisions depending on frequency range setting.

2.3.06 Data Updating: Selectable, continuous update on each frequency sweep or single update on one frequency sweep; two channels may be continually updated on alternate frequency sweeps; one channel may retain old data and second channel may be updated to display new data.

2.3.07 Trace Positioning: Both traces may be referred to the scale calibration; or, vertical positioning controls can separate the traces.

2.4 General Specifications

2.4.01 Recorder Output:

X Terminal: Output voltage proportional to send frequency.

Y Terminal: Output voltage proportional to receive level being stored.

Full Scale X or Y Output Level: 5 volts into a high impedance or 1 mA into 100 ohms.

Output Impedance: 4.9 k ohms (approximately).

2.4.02 Dial and Hold: Terminals are provided to attach a lineman's telephone set to dial a test number on a line under test. A switchable electronic hold circuit is provided to hold the line during measurements.

2.4.03 Environmental Conditions:

Operating Temperature: 0 to 50°C (to -25°C with reduced accuracy.)

Humidity: 95% at 35°C; 40% at 50°C

Storage Temperature: -55°C to +70°C

Altitude: (non-operating) 50,000 feet

2.4.04 Power: 115V/230V $\pm 10\%$, 50-60 Hz, 43 watts

2.4.05 Size: 10 3/8"H x 17 5/8"W x 17 3/4"D;
26.4 cm H x 44.8 cm W x 45 cm D.

2.4.06 Weight: 38 lbs. (16.3 kg)

3.0 PANEL CONTROLS AND CONNECTIONS

3.1 General

3.1.01 This section describes the function of each switch, control, lamp and connector external to the Model T195 Level Tracer.

3.1.02 This section is sub-divided into sections relating to input/output connections, input controls, output and amplifier controls, sweep controls, trace controls, display and vertical scale controls, and miscellaneous controls.

3.1.03 Figure 3-1 will locate the connections and controls by the subdivisions of this section.

3.1.04 Pushbutton action definitions—

- (1) Push-push: The switch remains engaged when pressed and must be pressed again to release. The switch function continues as long as the switch remains engaged.
- (2) Interlocking: Consists of a group of two or more switches. When any switch in a group is pressed, it automatically releases any other switch that was engaged. The switch function continues until released by pressing another switch in that group.
- (3) Interlocking with lockout: Has the same effects as the interlocking action except that no two interlocking buttons may be pressed at one time.
- (4) Momentary: The switch remains in only as long as it is pressed. The switch returns to its original position as soon as pressure is removed.
- (5) Engaged: The “in” or low profile position.
- (6) Released: The “out” or high profile position.

3.2 Input/Output Connections

3.2.01 ac Power Receptacle — This is a 3-prong male plug recessed in the rear panel of the test set. The line cord supplied with the test set supplies ac power to the test set through this connection.

3.2.02 Fuse — The snap-action fuse holder is located just to the left of the ac Power Receptacle. This 2 ampere fuse provides protection to the test set.

3.2.03 115V/230V Switch — On units having serial number 178 and higher this switch provides dual ac power capability.

3.2.04 RECORDER output binding posts —

- (1) X provides output proportional to frequency for connection to an xy recorder;
- (2) Y provides output proportional to measured data for connection to an xy recorder.

3.2.05 LINE-1, LINE-2, STD — These three pairs of binding posts are used for connection of circuits to be measured. The STD pair may be used to connect a standard for comparison with circuits connected to LINE-1 or

LINE-2. Any two pairs may be selected for testing and comparison by pressing the desired COMPARE pushbutton. A dialed-up connection may be held on either LINE-1 or LINE-2 terminals.

3.2.06 EXTERNAL NETWORK — A six-pin connector in parallel with two binding posts is used for connection of a precision network or special network if required to test various types of circuit. The six-pin connector is provided to accept a Wilcom precision network, which is part of the Model T240 Artificial Cable Kit. The build-out capacitor (B.O. CAP) is internally connected across these terminals when D66 or H88 IMPEDANCE COMPENSATOR pushbuttons are not engaged. If not needed, the B.O. CAP should be set at zero.

3.2.07 SEND output binding posts — The T and R terminals allow connection of the internal oscillator's output signal to a circuit under test. GND terminal is used to connect the Level Tracer's chassis ground to the ground of the circuit under test, if required. A dialed-up connection may be held on the SEND terminals.

3.2.08 DIAL Terminals — Two square metal posts allow connection of a lineman's telephone set when it is necessary to dial through the Level Tracer.

3.3 Input Controls

3.3.01 COMPARE: L1/L2, L1/STD, L2/STD — Three pushbuttons having interlocking with lockout action are used to select two inputs for comparison. Pressing L1/L2 will allow LINE-1 and LINE-2 to be connected to the measuring circuits. Pressing L1/STD or L2/STD will allow the corresponding pair of inputs to be connected to the measuring circuits.

NOTE: The actual connection of the selected inputs to the measuring circuits is controlled by the ASSIGN INPUT pushbuttons for the two traces. When the traces are assigned separate inputs, the inputs are alternately connected to the measuring circuits. When both traces are assigned to the same input, that input is continuously connected to the measuring circuit and the other input is open circuited.

3.3.02 LINE-1: HOLD, DIAL — Two pushbuttons with push-push action. Pressing to engage the DIAL pushbutton will connect the LINE-1 terminals to the DIAL posts. When the DIAL pushbutton is released, the LINE-1 terminals are connected to the measuring circuits. When the HOLD pushbutton is engaged, a dialed-up connection will be held.

3.3.03 LINE-2: HOLD, DIAL — Two pushbuttons with push-push action perform the functions of Section 3.3.02 for LINE-2.

NOTE: LINE-1/DIAL and LINE-2/DIAL pushbuttons have a mechanical lockout feature to ensure that only one DIAL pushbutton is engaged at any one time.

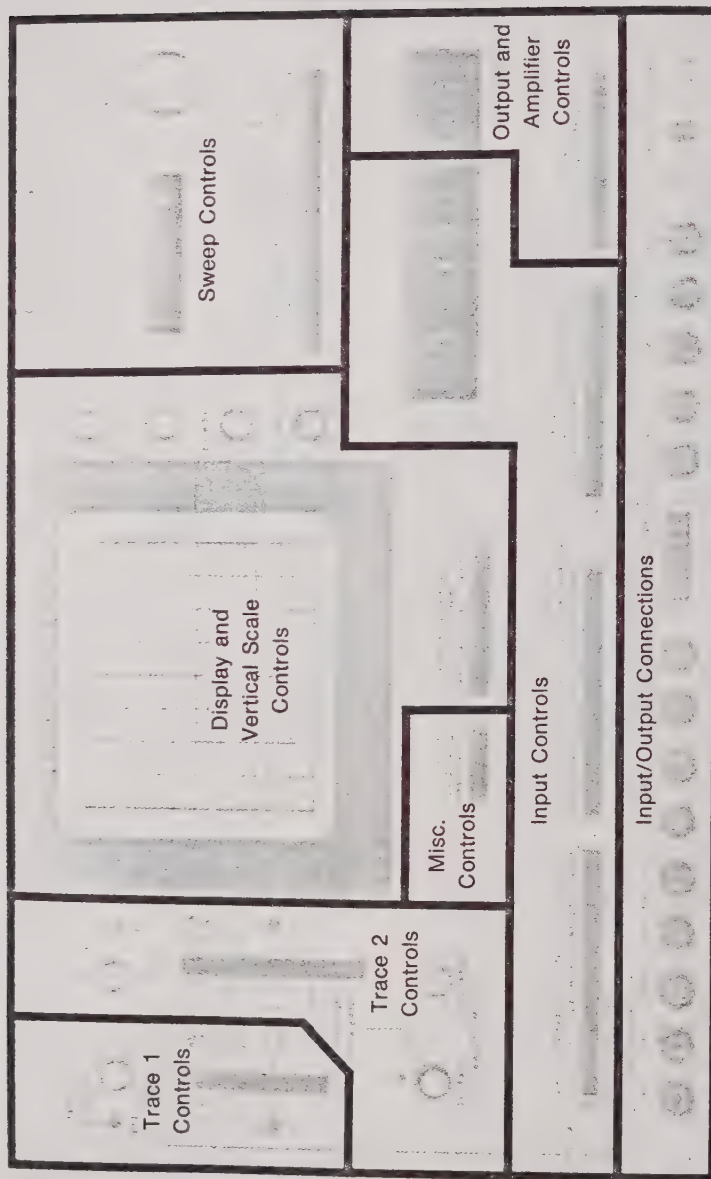


Figure 3-1 Connections and Controls

3.3.04 INPUT IMPEDANCE: BRDG, TERM – Two pushbuttons having interlocking action - when pressed, select either a bridging or terminated input impedance for LEVEL measurements on the LINE-1, LINE-2, and STD input terminals.

3.3.05 INPUT IMPEDANCE: 150, 600, 900 – Three pushbuttons having interlocking action - when pressed, select the input impedance for LEVEL measurements on the LINE-1, LINE-2, and STD input terminals. These pushbuttons do not affect RTN LOSS or IMP measurements.

3.3.06 IMPEDANCE COMPENSATOR: D66, H88 – Two pushbuttons having push-push action. When either pushbutton is engaged the capacitance selected with B.O. CAP μF is connected across the input terminals with an inductor (D66 = 33 mH, H88 = 44 mH) in series between the input terminals and the measuring circuit input. If not needed, the B.O. CAP should be set at zero.

3.3.07 FUNCTION: LEVEL, RTN LOSS, IMP – Three pushbuttons having interlocking with lockout action. When pressed, determines the connections between the input terminals, the measuring circuits and the output amplifier for the type of test to be made.

3.3.08 RET LOSS NET: EXT, 600, 900 – Three pushbuttons having interlocking action. The 600 and 900 buttons, when pressed, select a COMPROMISE NET consisting of 600 or 900 ohms in series with 2.16 μF . The EXT button, when pressed, selects the EXTERNAL NETWORK either the binding posts or the six-pin connector. Schematic detail is shown in the OPERATING INSTRUCTIONS section of the manual.

3.3.09 RECEIVE dBm – This two digit thumbwheel switch establishes the CRT 0dB reference point. When the LEVEL function button is engaged, the thumbwheel setting indicates the level, in dBm, at the zero dB point on the CRT vertical scale. When the RTN LOSS button is engaged, the thumbwheel setting indicates the return loss, in dB at the zero point on the CRT providing the SEND dBm thumbwheel switch is set to 0 dBm. When the IMP button is engaged, the RECEIVE dBm thumbwheel is inoperative.

3.3.10 B.O. CAP μF – This three digit thumbwheel switch sets the value of an internal, step variable, capacitor through a range of 0 to 0.999 μF in 0.001 μF steps. Capacitor location for specific functions is described in sections 3.2.05 and 3.3.06. If not needed, the B.O. CAP should be set at zero.

3.4 Output and Amplifier Controls

3.4.01 SEND: IMPEDANCE, 150, 600, 900 – Three pushbuttons having interlocking action - when pressed, select the output impedance for the SEND terminals. The impedance selection applies only to LEVEL measurements.

3.4.02 SEND: DIAL, HOLD – Two pushbuttons with push-push action perform the functions of Section 3.3.02 on the SEND terminals.

NOTE: The SEND/DIAL pushbutton switch is electrically interlocked with both LINE/DIAL pushbut-

tons such that when the SEND/DIAL pushbutton is engaged only the SEND terminals may be connected to the DIAL posts.

3.4.03 SEND dBm – This two digit thumbwheel switch sets the signal level applied to the SEND terminals when the LEVEL button is engaged and sets the signal level at which return loss measurements are made when the RTN LOSS button is engaged. When the IMP button is engaged, the SEND dBm must be set at zero for correct impedance readings.

3.5 Sweep Controls

3.5.01 FREQ RANGE Hz: 400, 4K, 8K, 20K – Four pushbuttons having interlocking action. Each pushbutton, when pressed, selects the high end of the frequency range for both the SEND generator and measurement display over the full horizontal CRT scale. Each range starts at 20 Hz.

3.5.02 2600 SKIP – A single pushbutton having push-push action. When engaged, the Level Tracer stops sending when the tuning enters the band between 2450 and 2750 Hz. Any characteristic pattern displayed on frequency ranges of 4K, 8K, or 20K will show a drop-out over this band.

3.5.03 TUNING: MAN, SW, TRACK – Three pushbuttons having interlocking action with lockout. When the MAN button is engaged, the 10 turn knob control designated MANUAL TUNING becomes operative and permits manual adjustment of the SEND frequency. When the SW button is engaged, the tuning is in an automatic sweep mode and will continuously sweep the selected FREQ RANGE Hz measurement range. When the TRACK button is engaged, the tuning control of the Level Tracer will automatically be "locked-on" and track the frequency of an incoming level signal within the limits specified in Section 2.2.11. The 5-digit LED display, SEND FREQUENCY, displays the measurement frequency to which the instrument is presently set via sweep, track, or manual tuning.

3.5.04 SWEEP: SLOW/FAST – A two position toggle switch selects the measurement frequency sweep rate when the SW button is engaged. The sweep rates are approximately 1.5 sec for FAST and 5 sec for SLOW.

3.5.05 0-CAL – A screwdriver adjustment to calibrate the instrument for 0 Hz at the low end of the measurement frequency range.

3.6 TRACE 1 Controls

3.6.01 REF/V-POS – A two position toggle switch, and associated knob control. When the switch is set to REF, the trace is in a fixed vertical position referenced to the vertical scale calibration. When set to V-POS, the position of the trace is controlled by the 270° rotation V-POS knob control.

3.6.02 ASSIGN INPUT: OUT-A, IN-B – A pushbutton having push-push action. Assigns trace 1 to display one of the three inputs as selected by the COMPARE pushbuttons (Section 3.3.01). When engaged, trace 1 will display either L2 or STD; when released, trace 1 will display either L1 or L2.

3.6.03 CONTINUOUS UPDATE — A pushbutton having push-push action. When engaged, the information displayed on trace 1 is continuously updated and the red LED is illuminated to indicate that the information on the next sweep for trace 1 will be stored. If trace 2 is displaying a second COMPARE input, the two traces are updated alternately.

3.6.04 SINGLE UPDATE — A pushbutton having momentary action with interlock to the CONTINUOUS UPDATE button. When pressed, the information from the next single sweep of trace 1 is stored and displayed. The red LED is illuminated until the **beginning** of the sweep that is updating the trace.

3.6.05 CLEAR — A pushbutton having momentary action. When pressed, instantly clears the information stored and displayed for trace 1.

3.7 TRACE 2 Controls

3.7.01 REV/V-POS — A two position toggle switch, and associated knob control. When the switch is set to REF, the trace is in a fixed vertical position referenced to the vertical scale calibration. When set to V-POS, the position of the trace is controlled by the 270° rotation V-POS knob control.

3.7.02 ASSIGN INPUT: OUT-B, IN-A — A pushbutton having push-push action. Assigns trace 2 to display one of the three inputs as selected by the COMPARE pushbuttons (Section 3.3.01). When engaged, trace 2 will display either L1 or L2; when released, trace 2 will display either L2 or STD.

3.7.03 CONTINUOUS UPDATE — A pushbutton having push-push action. When engaged, the information displayed on trace 2 is continuously updated and the red LED is illuminated to indicate that the information on the next sweep for trace 2 will be stored. If trace 1 is displaying a second COMPARE input, the two traces are updated alternately.

3.7.04 SINGLE UPDATE — A pushbutton having momentary action with interlock to the CONTINUOUS UPDATE button. When pressed, the information from the next single sweep of trace 2 is stored and displayed. The red LED is illuminated until the **beginning** of the sweep that is updating the trace.

3.7.05 CLEAR — A pushbutton having momentary action. When pressed, instantly clears the information stored and displayed for trace 2.

3.7.06 AVERAGE OVER BAND — A pushbutton having push-push action. When engaged, information displayed on trace 2 is averaged over a frequency band set by the LO FREQ and HI FREQ controls for BAND LIMITS. A straight horizontal line will be displayed representing the average value for the selected portion of the characteristic being measured.

3.7.07 BAND LIMITS: LO FREQ, HI FREQ — Two knob controls having 270° rotation. When the AVERAGE OVER BAND pushbutton is engaged, set the frequency band limits for the average function.

3.8 Display and Vertical Scale Controls

3.8.01 FOCUS — A knob having 270° rotation. Used in conjunction with the ASTIG control to obtain a well-defined display. Adjust for minimum trace width.

3.8.02 ASTIG — A knob having 270° rotation. Used in conjunction with the FOCUS control to obtain a well-defined display. Adjust for equal focus of horizontal and vertical segments of display.

3.8.03 HOR POS — A knob having 270° rotation. Provides control of the horizontal position of the display.

3.8.04 INTENSITY — A knob having 270° rotation. Controls the brightness of the display.

3.8.05 VERTICAL SCALE MULTIPLIER: X1, X2, X5, X10 — Four pushbuttons having interlocking action with lockout. Select the CRT vertical deflection scale factor. When the X1 pushbutton is engaged, the vertical scale values are read directly from the graticule. When the X2, X5, or X10 pushbutton is engaged, the vertical scale values are multiplied by the corresponding factor.

3.9 Miscellaneous Controls

3.9.01 FREQ MARK — A pushbutton having push-push action. When engaged, a frequency marker appears on both traces in the form of a short vertical line. The marker indicates the SEND frequency with respect to the graticule horizontal scale. By using manual send tuning, the marker can be positioned at any point on a stored trace and the corresponding frequency read from the SEND FREQUENCY digital display.

3.9.02 LOW FREQ REJ — A pushbutton having push-push action. When engaged, the instrument's low frequency response is attenuated to reject 60 Hz hum interference.

OPERATING INSTRUCTIONS

4.1 General

4.1.01 For operation, connect the line cord, supplied with the test set, to the recessed male connector on the rear panel. Set the voltage slide switch to either 115V or 230V position depending on the line voltage which will be used. The other end of the cord may be plugged into any 115 or 230 volt three-wire convenience outlet. Power is supplied to the test set by pushing the POWER pushbutton. The integral lamp indicates that power is being supplied to the test set.

4.1.02 After power has been applied, the set will be ready to use as soon as the cathode ray tube display is visible. The frequency calibration may drift for a short period, particularly if the set has been stored in a cold environment for some time. Ample time should elapse to allow the set to warm-up before the 0 CAL control is adjusted in accordance with 4.2.01. No other calibration is required.

4.2 Initial Conditions

4.2.01 During initial familiarization with the Level Tracer, all switches and controls should first be set to the following positions. The operating instructions of this section assume these initial conditions have been established.

1. Set all controls as follows:

SPACE 1 & 2: toggle switches	REF
SPACE 1 & 2: ASSIGN INPUT	Engaged
TRACE 1 & 2: CONTINUOUS UPDATE	Engaged
TRACE 2 AVERAGE OVER BAND	Released
COMPARE: L1/L2	Engaged
LINE 1 & 2: HOLD	Released
LINE 1 & 2: DIAL	Released
INPUT IMPEDANCE: TERM	Engaged
INPUT IMPEDANCE: 600	Engaged
IMPEDANCE COMPENSATOR: D66 & 1/4"	Released
H88 FUNCTION: LEVEL	Engaged
RET LOSS NET: 600	Engaged
SEND IMPEDANCE: 600	Engaged
SEND: DIAL	Released
SEND: HOLD	Released
FREQ RANGE Hz: 8K	Engaged
2600 SKIP	Released
TUNING: SW	Engaged
SWEEP: SLOW/FAST	FAST
RECEIVE dBm	00
B.O. CAP uF	000
SEND dBm	00
VERTICAL SCALE MULTIPLIER: X10	Engaged
LOW FREQ REJ	Released
FREQ MARK	Engaged

NOTE: Pushbuttons having interlocking action with any shown "engaged" in the above list will be in the released position.

2. Install patch cord between LINE-1 and SEND terminals.

3. Adjust the INTENSITY, FOCUS, and ASTIG knobs for a well defined trace along the zero dB reference line. The input relay switching between traces should be audible.
4. After warm-up, calibrate the HOR POS as follows:
 - a. Engage the TUNING: MAN pushbutton and turn the MANUAL TUNING knob fully counterclockwise.
 - b. Adjust the screwdriver 0-CAL control for zero SEND FREQUENCY.
 - c. Adjust the MANUAL TUNING knob for a SEND FREQUENCY of 4000 Hz.
 - d. Adjust the HOR POS knob to center the frequency marker.
5. Engage the TUNING: SW pushbutton.
6. Engage FREQ RANGE Hz: 20K pushbutton.

4.3 Dial and Hold

4.3.01 To dial and hold a line:

1. Press to engage the DIAL pushbutton associated with the Level Tracer terminals in use.
2. Connect a lineman's test telephone to the dial posts and dial the required test number.
3. After reaching the test number, push to engage the HOLD pushbutton associated with the terminals in use.
4. Push to release the DIAL pushbutton.
5. The connection will now be held until dropped by pushing to release the HOLD pushbutton.

4.4 Sending Tones

4.4.01 The internal signal generator will provide either a manually adjustable or an automatic sweeping signal to a circuit under test.

4.4.02 A single frequency, non-sweeping signal is sent as follows:

1. Press to engage the TUNING: MAN pushbutton.
2. Press to engage the lowest frequency FREQ RANGE Hz pushbutton that is above the desired signal frequency. (A higher frequency range may be used with a loss in tuning sensitivity).
3. Adjust the MANUAL TUNING knob until the desired signal frequency is displayed as SEND FREQUENCY.
4. Push to engage the desired SEND IMPEDANCE pushbutton.
5. Adjust the two digit SEND dBm thumbwheel switch to display the desired signal level.

6. Verify the FUNCTION: LEVEL pushbutton is engaged.
7. The desired signal frequency and level is now present at the SEND terminals for connection to the circuit being tested.

4.4.03 An automatic sweeping signal is sent as follows:

1. Press to engage the TUNING: SW pushbutton.
2. Press to engage the FREQ RANGE Hz pushbutton to select the high frequency end of the sweep frequency range.
3. Select the desired sweep speed with the SWEEP: SLOW/FAST toggle switch.
4. Push to engage the desired SEND IMPEDANCE pushbutton.
5. Adjust the two digit SEND dBm thumbwheel switch to the desired signal level.
6. Verify the FUNCTION: LEVEL pushbutton is engaged.
7. The sweeping signal of selected range and level is now present at the SEND terminals for connection to the circuit being tested.

4.5 CRT Trace Display

4.5.01 The tuning controls for the internal generator also control the horizontal sweep of the CRT. The engaged FREQ RANGE Hz pushbutton determines the horizontal frequency scale while the horizontal position of the trace sweep is determined by the internal generator tuning (displayed as SEND FREQUENCY). When the TUNING: MAN pushbutton is engaged, the position of the sweep is controlled by the MANUAL TUNING knob - the internal generator must be manually tuned to sweep and update the CRT traces. When the TUNING: SW pushbutton is engaged, the internal generator automatic tuning also controls the CRT sweep. When the TUNING: TRACK pushbutton is engaged, an external signal must be applied to a measure input to control the internal tuning of the Level Tracer.

4.5.02 The CRT graticule scales are calibrated for direct reading of dB values or impedance values when the VERTICAL SCALE MULTIPLIER: X1 pushbutton is engaged - each vertical division is either 0.2 dB or 50 ohms. When either the X2 or X5 or X10 pushbutton is engaged, the vertical measurement display range is increased by the corresponding factor.

4.6 Line Selections and Updating the Display Traces

4.6.01 The two CRT traces (TRACE 1, TRACE 2) may be assigned, either simultaneously or individually, to display any two of the three measuring inputs (LINE-1, LINE-2, STD) and may be updated on successive sweeps or on an individual sweep basis.

4.6.02 The three COMPARE and two ASSIGN INPUT pushbuttons provide the means for selecting any two of the three measure inputs (Section 3.2.04) for storage and display

on the CRT. When the trace 1 ASSIGN INPUT pushbutton (designated OUT-A, IN-B) is engaged, INPUT B is selected. This will connect, as determined by the engaged COMPARE pushbutton, either the L2 or STD input to the trace 1 storage and display. When the trace 1 ASSIGN INPUT pushbutton is released, INPUT A is selected and either the L1 or L2 input is connected to trace 1. The trace 2 ASSIGN INPUT pushbutton (designated OUT-B, IN-A) works in a similar manner to connect the selected measure input to the trace 2 storage and display.

4.6.03 When the TUNING: SW pushbutton is engaged, the updating of stored and displayed information is controlled by the CONTINUOUS UPDATE and SINGLE UPDATE pushbuttons for each trace. When the CONTINUOUS UPDATE pushbutton for only one trace is engaged, that trace will be updated every time the CRT is swept. When both CONTINUOUS UPDATE pushbuttons are engaged, and the traces are assigned to separate inputs, each trace will be updated on alternate sweeps of the CRT. If both traces are assigned to the same input, both traces will be updated every time the CRT is swept. Pushing the SINGLE UPDATE pushbutton will cause the corresponding trace to be updated on the next sweep and will release the CONTINUOUS UPDATE button for that trace. When the red light next to the button goes out, information is being stored and displayed for the corresponding trace and will not change until an UPDATE pushbutton for that trace is again pressed.

4.6.04 When either the TUNING: TRACK or the TUNING: MAN pushbutton is engaged, only one trace may be selected for CONTINUOUS UPDATE. If both CONTINUOUS UPDATE pushbuttons are engaged, only trace 1 will be continuously updated - the trace 1 CONTINUOUS UPDATE must be released before the trace 2 CONTINUOUS UPDATE will be electrically activated. During TRACK or MAN operation the SINGLE UPDATE function is not operational because there are no sweep control signals available to control any single update.

4.6.05 Pushing either trace CLEAR pushbutton will instantly remove the stored and displayed information for the corresponding trace. The next sweep of the generator will store and display the measured characteristic if the CONTINUOUS UPDATE pushbutton is engaged.

4.6.06 Other trace controls are discussed in separate sections: V-POS/REF - Section 4.5; AVERAGE OVER BAND - Section 4.11.

4.7 Test Selection

4.7.01 The FUNCTION pushbuttons are used to select the type of testing operation to be performed. Push to engage LEVEL, RTN LOSS, or IMP. Other controls are then used to set up the instrument for the specific test operation. Detailed applications instructions are provided in Section 5.0 of the Applications Manual for specific test operations.

4.8 Level Measurements (LEVEL)

4.8.01 See Section 4.3 to dial and hold a line for LEVEL measurements.

4.8.02 Push to engage the **FUNCTION: LEVEL** pushbutton. Verify that the **DIAL** and **IMPEDANCE COMPENSATOR** pushbuttons are released and that both trace **V-POS/REF** toggle switches are in the **REF** position.

4.8.03 Referring to Section 4.6, select the measure inputs being used and assign traces for display.

4.8.04 The **INPUT IMPEDANCE** pushbuttons select either **BRDG** or **TERM** plus an appropriate impedance value (150, 600, or 900 ohms) for receiving/measuring on any circuit connected through the measure input connectors and line select and trace assign switches to the measuring circuits input.

4.8.05 The **RECEIVE dBm** thumbwheel switches determine the attenuation imposed on a signal being measured by the Level Tracer and indicate the level at 0 dB on the CRT vertical scale. These switches have no effect when the **IMP** function is selected.

4.8.06 The **FREQ RANGE Hz** pushbuttons determine the frequency range over which the measurement will be displayed, as well as the range of **SEND** frequency tuning.

4.8.07 When using the Level Tracer to make circuit loss (or gain) measurements, the test signal may be obtained from the Level Tracer's internal generator or from an external source. However, when using an external source or the internal generator in other than **SWEEP** Tuning mode, the user should be aware of the following operating principles:

1. The information stored and displayed represents the broad-band received signal level vertically, and the internal generator frequency at the time information was stored horizontally. The Level Tracer is not a spectrum analyzer.
2. A change in generator frequency is required to effect any entry of data into trace storage.
3. When the internal generator is used (see Section 4.4) it is normally set in **SWEEP** tuning mode. If the internal generator is in **MAN** and is set to a fixed frequency, no updating will occur. Now, if the manual tuning knob is turned, new data on the trace set for continuous update begin to appear as the send frequency changes.
4. When an external sweep generator is used, the internal generator should be set in **TRACK** tuning mode. The internal frequency will now track the received frequency and updating will take place as required.
5. When an external fixed frequency source is used, the internal generator should first be set in **SWEEP** tuning mode. Since the received level remains unchanged as the internal frequency sweeps, the trace will be a horizontal line across the screen. The received level is read from the trace position. Now switch the internal generator to **TRACK** mode. It will lock on to the received frequency, which can be read on the digital **SEND FREQUENCY** display.

4.8.08 Other controls (such as **LOW FREQ REJ**, **VERTICAL SCALE MULTIPLIER**, and **V-POS/REF**) that may also be useful in level tests are described separately in this section.

4.9 Impedance Measurements (IMP)

4.9.01 The Level Tracer generator is used internally for impedance measurements and is therefore not available at the **SEND** terminals when the **FUNCTION: IMP** pushbutton is engaged (FIG 4.1). **TUNING** may be either **SW** or **MAN**. The **FREQ RANGE Hz** pushbuttons determine the frequency range over which the measurement will be displayed.

4.9.02 Verify that the **DIAL** and **IMPEDANCE COMPENSATOR** pushbuttons are released and that both trace **V-POS/REF** toggle switches are in the **REF** position.

4.9.03 Referring to Section 4.6, select the measure inputs being used and assign traces for display.

4.9.04 The **SEND dBm** thumbwheel switches are normally set at 0 dBm for correct vertical CRT scaling to allow direct reading of impedance from the calibrated graticule. However, in certain cases it is useful to set the **SEND dBm** thumbwheel switches for other than 0 dBm to get better resolution of very low value impedances or extend the range for high value impedances. In such cases, impedance values can be obtained by reducing the reading determined from the CRT screen by the **SEND dBm** switch setting expressed as a ratio with respect to 0 dBm. This calculation is illustrated in the following examples:

Impedance Example 1

SEND dBm setting: +18 dBm = ratio of 8:1

CRT graticule impedance times **VERTICAL SCALE MULTIPLIER** = 100 ohms

Calculated value: $100 \text{ ohms} \div 8 = 12 \text{ ohms}$

NOTE: When measuring low impedance values, the 3 percent of vertical scale accuracy specification will become a significant portion of the measured value.

Impedance Example 2

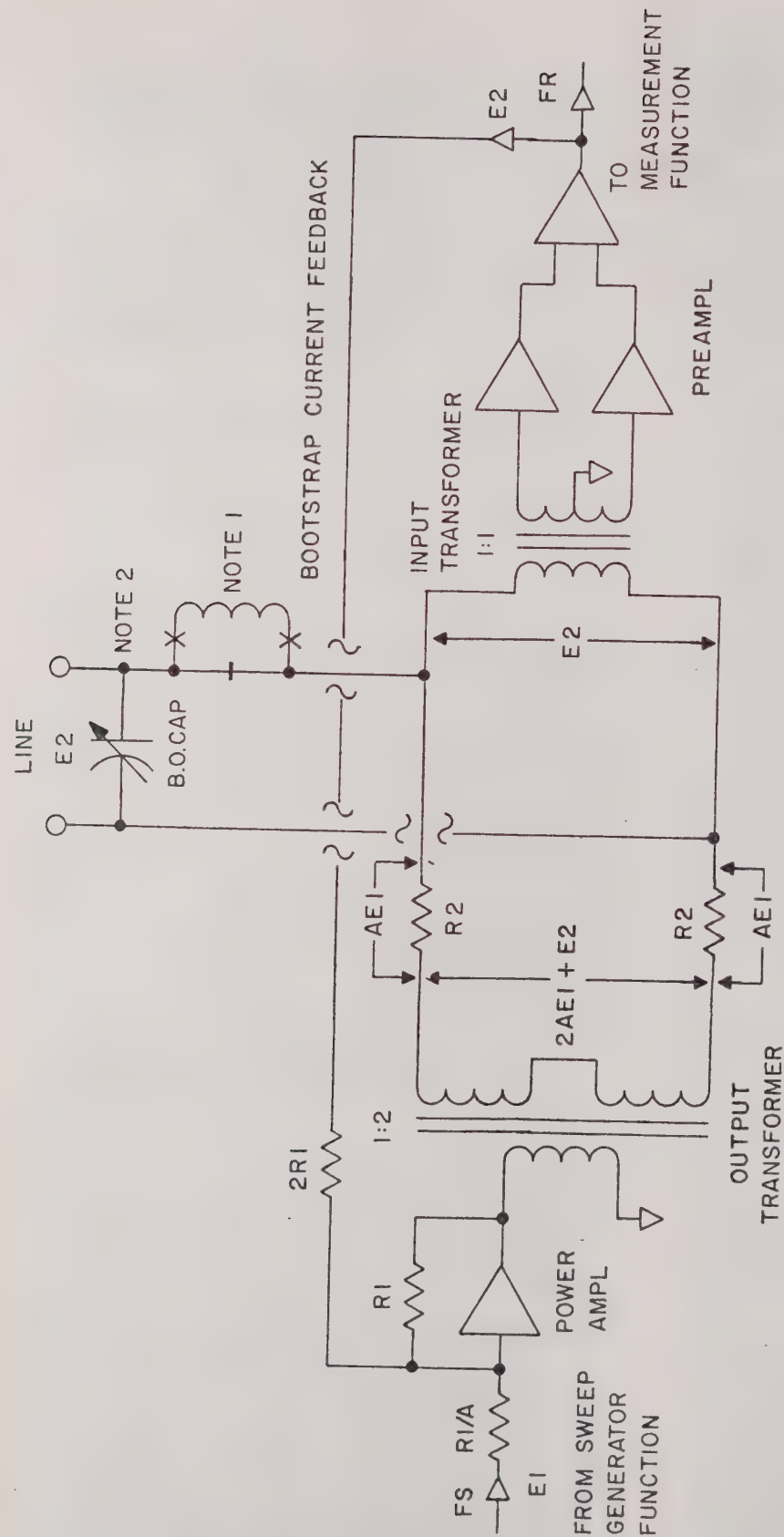
SEND dBm setting: -6 dBm = ratio of 0.5:1

CRT graticule impedance times **VERTICAL SCALE MULTIPLIER** = 7000 ohms

Calculated value: $7000 \text{ ohms} \div 0.5 = 14,000 \text{ ohms}$

NOTE: When expanding the measurement range above 10,000 ohms, input circuit loading will increasingly become a factor in the results with higher impedance and frequency.

4.9.05 Detailed applications instructions are provided in Section 5.0 of the Applications Manual for using the **IMPEDANCE COMPENSATOR** for cable measurements or the **B.O. CAP** for capacitance measurements with the impedance function. Other controls (such as **LOW FREQ REJ**, **VERTICAL SCALE MULTIPLIER**, and

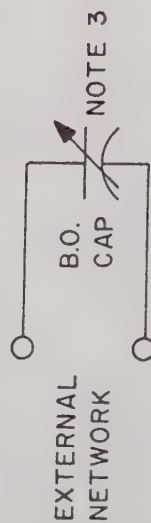


NOTES

1- 33mH OR 44mH INDUCTOR INSERTED WHEN D66 OR H88 IS ENGAGED.

2- B.O. CAP CONNECTED HERE IF D66 OR H88 IS ENGAGED.

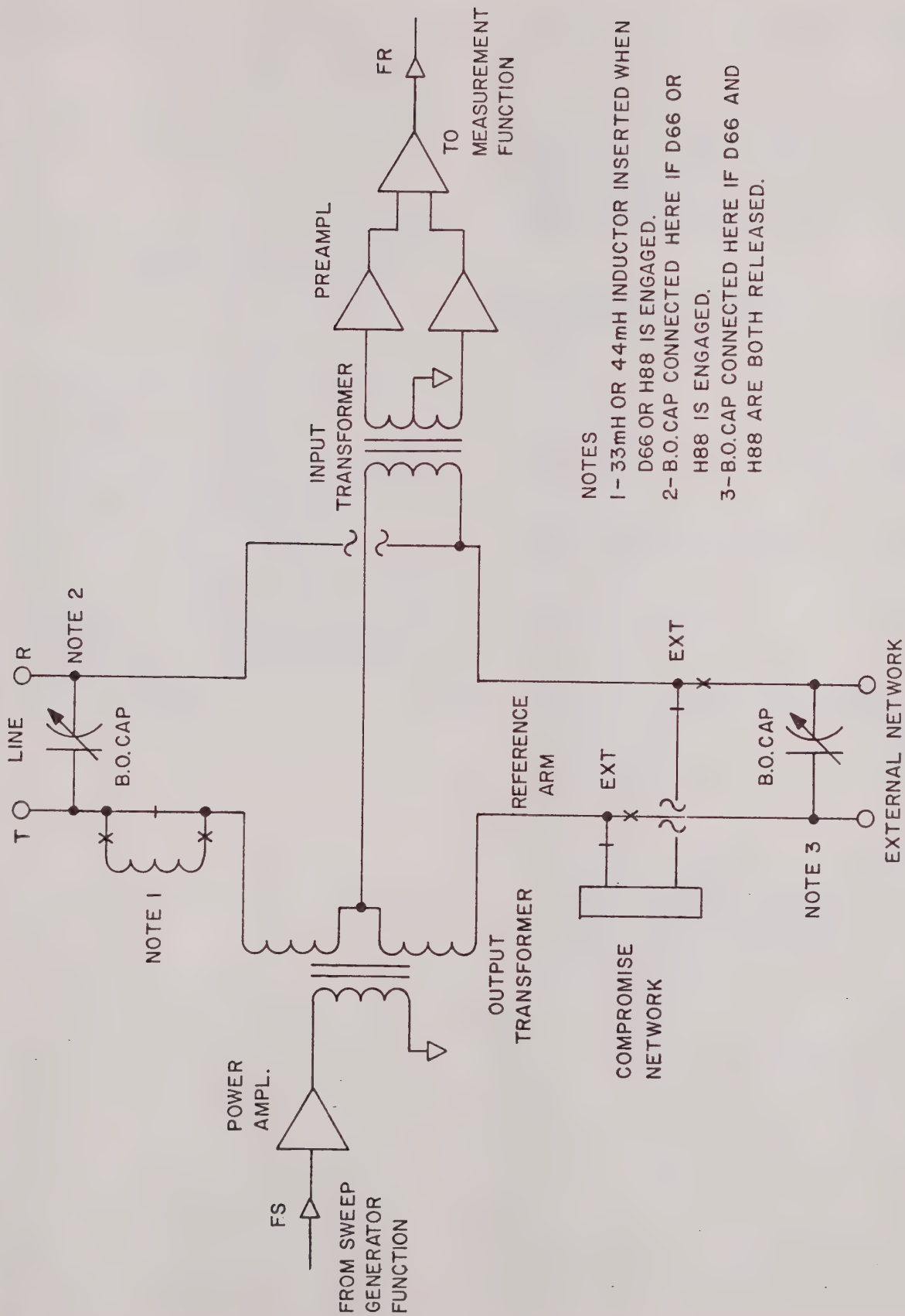
3- B.O. CAP CONNECTED HERE IF D66 AND H88 ARE BOTH RELEASED.



$$E2 = (2AE1 + E2) \frac{Z_{LINE}}{Z_{LINE} + 2R2} = AE1 \frac{Z_{LINE}}{R2}$$

BLOCK DIAGRAM - IMPEDANCE TEST

Fig. 4-1



NOTES

1- 33mH OR 44mH INDUCTOR INSERTED WHEN D66 OR H88 IS ENGAGED.

2- B.O.CAP CONNECTED HERE IF D66 OR H88 IS ENGAGED.

3- B.O.CAP CONNECTED HERE IF D66 AND H88 ARE BOTH RELEASED.

Block Diagram - Return Loss Test

Fig. 4-2

AVERAGE OVER BAND) that may also be useful in impedance tests are described separately in this section.

4.10 Return Loss Measurements (RET LOSS)

4.10.01 The Level Tracer generator is used internally for return loss measurements and is therefore not available at the SEND terminals when the FUNCTION: RTN LOSS pushbutton is engaged (FIG 4.2). TUNING may be either SW or MAN. The FREQ RANGE Hz pushbuttons determine the frequency range over which the measurement will be displayed.

4.10.02 Verify that the DIAL and IMPEDANCE COMPENSATOR pushbuttons are released and that both trace V-POS/REF toggle switches are in the REF position.

4.10.03 Referring to Section 4.6, select the measure inputs being used and assign traces for display.

4.10.04 The reference against which the return loss is measured is selected by engaging one of the three RET LOSS NET pushbuttons (SECTION 3.3.08). Since internal switching places the B.O. CAP across the INTERNAL NETWORK terminals when both IMPEDANCE COMPENSATOR pushbuttons are released, the B.O. CAP may be used as all or part of the reference. When not needed, the B.O. CAP thumbwheel switches should be set at zero.

4.10.05 Normally, when the FUNCTION: RTN LOSS pushbutton is engaged, the SEND dBm thumbwheel switches are set to zero. The 0 dB point on the graticule is then a calibrated reference line as determined by the setting of the RECEIVE dBm thumbwheel switches. The return loss is the algebraic sum of the RECEIVE dBm thumbwheel switch setting and the deflection in dB (including VERTICAL SCALE MULTIPLIER) of the CRT trace from the 0 dB reference line, with the sign reversed. (More negative received level represents more positive return loss.)

4.10.06 In certain cases it may be useful to set the SEND dBm thumbwheel switches for other than 0 dBm. This can be helpful when measuring large return loss values or when the instrument is used for comparison bridge measurements as described in the Applications Manual. The return loss is then determined by algebraically summing the RECEIVE dBm setting with the value determined from the screen, reversing the sign, and then adding the SEND dBm setting.

4.10.07 Two typical return loss calculations are illustrated in the following examples.

Return Loss Example 1

RECEIVE dBm setting = -20 dB

CRT trace deflection from 0 dB graticule times
VERTICAL SCALE MULTIPLIER = -5 dB

SEND dBm setting = 0

Calculated value: $- [(-20) + (-5)] + (0) = 25 \text{ dB}$

Return Loss Example 2

RECEIVE dBm setting = -30 dB

CRT trace deflection from 0 dB graticule times
VERTICAL SCALE MULTIPLIER = -5 dB

SEND dBm setting = +5 dB

Calculated value: $- [(-30) + (-5)] + (+5) = 40 \text{ dB}$

4.10.08 Other controls (such as LOW FREQ REJ, VERTICAL SCALE MULTIPLIER, and AVERAGE OVER BAND) that may also be useful in Return Loss measurements are described separately in this section.

4.11 AVERAGE OVER BAND Function

4.11.01 The AVERAGE OVER BAND pushbutton (Section 3.7.06) is usually engaged only for impedance and return loss measurements. The LO FREQ and HI FREQ controls set the low and high limits over which the average measured value is displayed as a straight line. When averaging a portion of the CRT display the TUNING: MAN pushbutton may be engaged and the desired band limits frequencies set using the frequency marker position and the displayed SEND FREQUENCY.

4.12 LOW FREQ REJ Function

4.12.01 The LOW FREQ REJ pushbutton (Section 3.9.02) may be engaged during any of the Level Tracer measurement functions to reduce the effect of low frequency noise on the characteristic being displayed. The function is particularly useful when measuring low signal levels or high return loss levels with high levels of 60 Hz induced noise.

5.0 CIRCUIT DESCRIPTION

5.1 General

5.1.01 This section describes the T195's internal circuits and their functions. The section is organized much like a self-teaching textbook. Presentation of concepts and explanations move from general to specific via a series of levels, each level providing more detailed diagrams and descriptions.

5.1.02 The descriptive levels are as follows:

1. **Block Diagram Description** (para 5.2) introduces the basic internal functions and the most important signal paths between functions.
2. **Functional Diagram Description** (para 5.3) explains major operations performed within the functions and shows additional signal connections.
3. **Schematic Diagram Description** (para 5.4) provides detailed circuit theory and signal interconnection information for all assemblies of the T195. (The simplified schematic diagram which accompanies this descriptive level shows all connector pin numbers, test points, and internal adjustments. The diagram can be used as an aid when trouble-shooting or aligning the T195.)

Block Diagram Description

5.2.01 Figure 5-1 is a simplified block diagram which shows the Level Tracer's five major internal functions. These are:

1. In/Out Switching Function
2. Measurement Function
3. Data Conversion, Storage and Cathode-Ray Tube Display Function
4. Generator Function
5. Digital Frequency Display Function

5.2.02 The In/Out Switching Function provides switch-selectable interfacing between the T195 and external telephone equipment connected to the instrument. The IN/OUT Function contains the internal circuits which configure the instrument properly for desired types of tests (LEVEL, IMP, and RTN LOSS).

5.2.03 The In/Out function also contains the panel switches (L1/L2, L1/STD, L2/STD) which select a pair of the T195's three inputs (LINE-1, LINE-2, STD) for testing. A relay within the In/Out Function then determines which input of the selected pair will actually be tested at any instant. The relay is controlled by the INPUT SELECT signal shown on figure 5-1.

5.2.04 The INPUT SELECT signal is produced by the Data Conversion, Storage and CRT Display Function ac-

cording to the status of the CONTINUOUS/SINGLE UPDATE switches associated with that function. Depending on switch settings, the INPUT SELECT signal may continuously or periodically specify either input of a pair for testing. Testing may alternate between two inputs on successive frequency sweeps of the T195.

5.2.05 When an input is selected for any measurement, the signal resulting from that measurement appears on the FR (FREQ RECEIVE) signal path shown by Figure 5-1. The FR path is presented to the measurement function for processing as described in later paragraphs.

5.2.06 The T195's internally produced test signal frequency is presented to the In/Out Switching Function on the FS (FREQ SEND) path from the Generator Function. The FS signal has a frequency range of 20 Hz to 20 kHz.

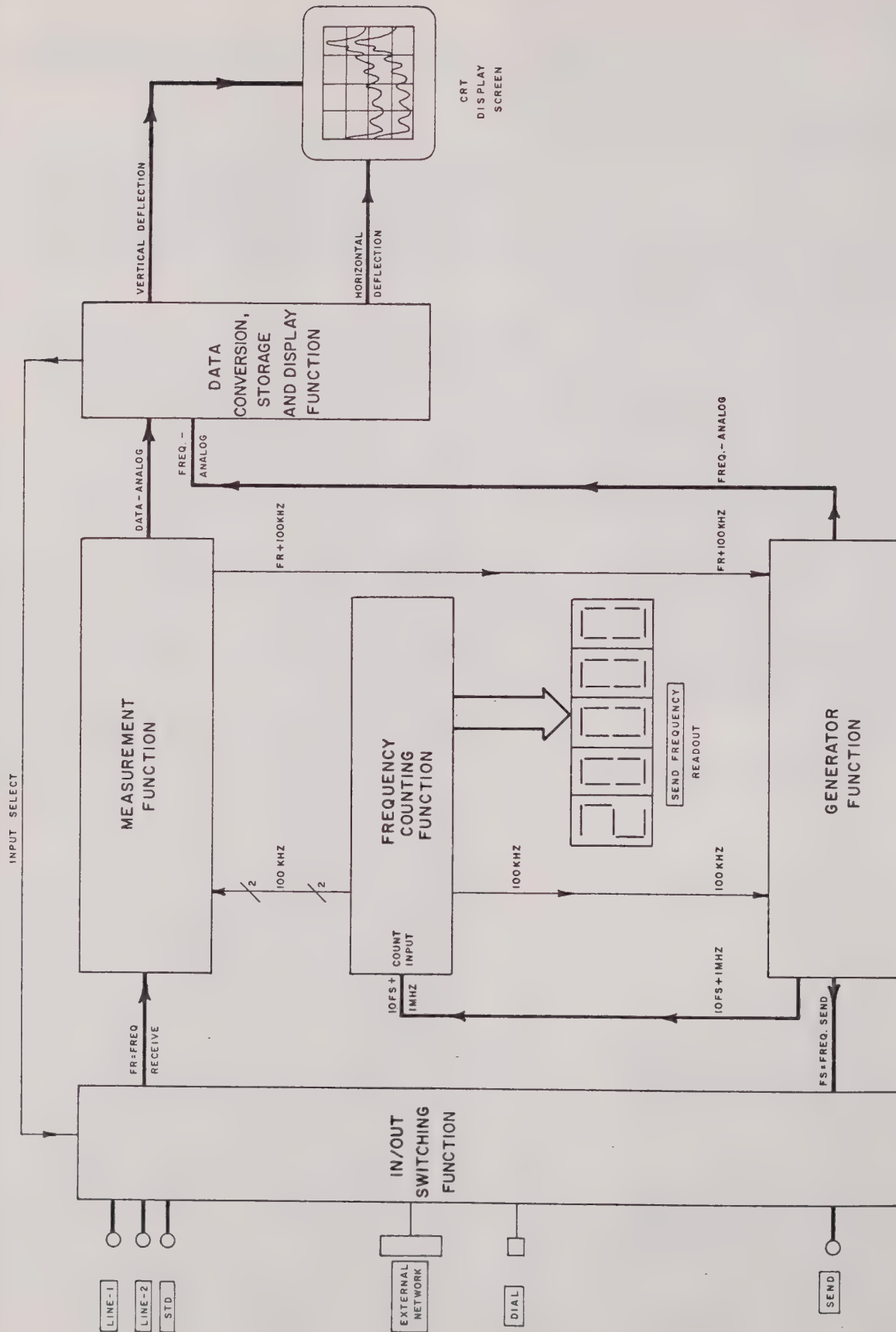
5.2.07 During LEVEL measurements, the In/Out Switching Function connects the FS signal to the T195's SEND terminals for transmission into a telephone circuit under test, if required. During IMP (impedance) and RTN LOSS (return loss) measurements, the FS signal is used internally by the In/Out Switching Function to "excite" the function's measuring circuits.

5.2.08 The In/Out Switching Function also provides:

1. For selecting send and receive impedances (150, 600, 900) in level measurements;
2. For dialing through and holding telephone circuits connected to the T195;
3. For use of an adjustable, internal build-out capacitor (B.O. CAP) as required;
4. For termination of telephone circuits under test with either D66 or H88 impedance compensation, or with no compensation, as required;
5. For use of an external precision network or an internal compromise network in return loss measurements.

5.2.09 The Measurement Function accepts "raw" measurement signals from the FR path shown in Figure 5-1. The function processes the "raw" signals according to the type of test selected (LEVEL, IMP, RTN LOSS) and the settings of other panel controls. The result of this processing is a dc signal (called DATA-ANALOG) which is scaled to properly convey the measurement information to the Data Conversion, Storage and CRT Display Function.

5.2.10 The Measurement Function uses 100 kHz reference signals from the Frequency Display Function to up-convert the frequency of the FR measurement signals being processed. The up-conversion aids in processing as will be described in the more detailed portions of this section. The up-conversion also results in a signal called FR +



T195 LEVEL TRACER
SIMPLIFIED BLOCK DIAGRAM

Fig. 5-1

100 kHz which is used by the sweep generator function to lock on and follow the frequency of an input being received by the T195 when operating in TRACK mode.

5.2.11 The Data Conversion, Storage and Cathode-Ray-Tube Display Function accepts processed measurement information as a dc signal on the DATA-ANALOG path from the Measurement Function. The incoming DATA-ANALOG signal is sampled periodically, and each sample is changed to digital data by an analog-to-digital (A/D) converter.

5.2.12 The digitized measurement data samples are presented to two solid state memories, one memory for each of the T195's two CRT traces. The measurement data samples can be written into (stored in) either or both of the memories, depending on status of the T195's ASSIGN INPUT and CONTINUOUS or SINGLE UPDATE controls.

5.2.13 Whatever data is stored in the memory for each trace will be used to create that trace's display on the CRT screen. The ASSIGN INPUT and the CONTINUOUS/SINGLE UPDATE controls permit measurement data to be stored and retained in either or both of the memories as desired, continuously or periodically. This makes possible a number of capabilities as follows:

1. A single set of measurement data samples for a single telephone circuit under test can be stored in both memories, in which case both traces show the same data.
2. Data samples from one measurement can be stored in one memory, and data samples from a later measurement on the same (or a different) telephone circuit can be stored in the second memory. In this case, one trace will show data from the first measurement, and the other trace will show data from the second measurement.
3. If two different telephone circuits are connected to the T195 at the same time, data from measurements on one circuit can be written into one memory for display on one trace. And, data from measurements on the other circuit can be written into the other memory for display on the other trace. This process can occur automatically and continuously, measuring two telephone circuits on alternate sweeps of the send frequency generator.

5.2.14 It should be noted that only one set of measurement data samples can be obtained, processed and stored in memory at any given time. This results from the fact that there is only one FR signal path, one measurement function, and one DATA-ANALOG signal path in the T195. This single measurement path is shared between the LINE-1, LINE-2, and STD inputs which have been selected by the In/Out Switching Function. If measurements are to be made on two inputs, then one is processed first and its data samples are stored in one trace memory. The second input is then processed, and its measurement data samples are stored in the second trace memory.

5.2.15 While the Conversion, Storage and CRT Display Function is sampling and storing measurement data, the function is also receiving a signal called FREQ-ANALOG. The FREQ-ANALOG signal originates in the Generator Function. It is the dc command voltage which controls the frequency to which the T195 is tuned at any given instant. That is, the FREQ-ANALOG dc voltage is proportional to the FS signal frequency being produced by the Generator Function.

5.2.16 The Conversion, Storage and Display Function receives the FREQ-ANALOG signal to identify the measurement frequency of each data sample being stored in memory. This allows each measurement data sample to be stored at a particular location (address) in the memory which corresponds to a specific frequency in the T195's tuning range. (Information on this process is provided in the more detailed portions of this section.)

5.2.17 This storage method permits the T195 to easily recall measurement data for generation of the frequency versus measurement amplitude traces which appear on the CRT screen. The instrument simply cycles through the memory addresses one-after-the-other and reads out the measurement data samples stored at those addresses.

5.2.18 As the data samples are being read out from the memory, they are changed back to analog form by a digital-to-analog (D/A) converter. The converter's output signal is then used to create the vertical deflection signal which supplies measurement amplitude information to the CRT screen.

5.2.19 Only one D/A converter is used to create both traces. To accomplish this, the converter examines first the contents of one trace memory and then the contents of the second trace memory.

5.2.20 The memory read-out/trace-generation operations are timed such that they occur continuously, even while new measurement data samples are being written into the trace memories. Actually, the read-out operations occur much faster than the write-in operations so that multiple sample read-outs can be interleaved between each sample write-in.

5.2.21 The horizontal deflection signal which supplies sweep (frequency) information to the CRT is also generated within the Data Conversion, Storage, and Display Function. The horizontal deflection signal is derived from the same circuits which read-out the contents of the trace memory addresses. Thus, there is a direct correspondence between the frequency at which a data sample was taken and the horizontal position on a trace where that sample appears.

5.2.22 The above operations (and additional operations) performed by the Data Conversion, Storage and Display Function are described more fully in later paragraphs of this section.

5.2.23 The Generator Function is a precision, variable oscillator which can be: (a) manually tuned, or (b) swept automatically across a frequency band, or (c) caused to track the frequency of an external signal source. The signal

used in measurements by the T195 is called FS (FREQ SEND) on Figure 5-1. The FS signal has a range of 20 Hz to 20,000 Hz as described previously.

5.2.24 The FS Signal can be passed by the In/Out Switching Function to the SEND terminals for use in level testing. The FS Signal is used internally within the In/Out Switching Function during impedance and return loss measurements.

5.2.25 The FS output of the Generator Function is actually derived from a signal whose frequency is between 1.0 to 1.2 MHz. This frequency band is covered by a voltage-controlled-oscillator (VCO) within the Generator Function. The VCO's actual output (covering a 1.0 to 1.2 MHz band) is the 10 FS + 1 MHz signal shown on Figure 5-1.

5.2.26 The Frequency Display Function is designed to accept the 10FS + 1 MHz (1.0 to 1.2 MHz) signal and produce a SEND FREQUENCY digital display of the FS (20 to 20,000 Hz) signal derived from it. Note also that the frequency counting function produces a 100 kHz reference frequency which the generator function uses in its down conversion from the VCO's high band to the FS signal's lower band. (These and other internal operations of the frequency counting and generator functions will be described in detail later in this section.)

5.3 Functional Diagram Description

5.3.01 Figure 5-2 is a functional diagram of the T195 which shows basic operations performed within the instrument's major functions. Refer to this diagram for aid in understanding the following descriptions.

5.3.02 In/Out Switching Function

5.3.02.01 The instrument's three possible measurement inputs are shown by heavy lines at the top left of Figure 5-2. The L1/L2, L1/STD, and L2/STD switches are used to select any two out of the three possible inputs for measurements by the instrument.

5.3.02.02 An additional selection is accomplished by relay K1 to determine which of the two selected inputs will be measured at any given time. Relay K1 is controlled by the INPUT SELECT signal which depends on the status of the T195's ASSIGN INPUT, CONTINUOUS UPDATE, and SINGLE UPDATE controls. Relay K1 allows the T195 to operate much like a dual-trace oscilloscope. The relay can select either one of the inputs individually for measurements specified by the T195's user. Or, the relay can switch back and forth between the two inputs on alternate generator sweeps for measurements on one, then the other.

5.3.02.03 Note that the LINE-1, LINE-2, and SEND terminal pairs can each be switched to the front panel DIAL posts. Thus, a lineman's telephone set may be connected to the single set of DIAL posts and be used to place calls over telephone circuits connected to any of the LINE or SEND terminal pairs. Also note that each of the LINE and SEND terminal pairs is equipped with its own switch-selectable hold circuit. When switched in, any of the hold circuits will maintain proper dc loop holding current while presenting a high ac impedance across its terminal pair.

5.3.02.04 The LEVEL, IMP, and RTN LOSS switches configure the Level Tracer's In/Out Function for the different types of measurements. It is difficult to picture the three measurement configurations from looking at Figure 5-2. Therefore, the three measurement configurations are shown in simplified form on Figures 5-3 through 5-5.

5.3.02.05 In level measurement configuration (Fig. 5-3); the receive signal input from a line under test is transformer coupled to the preamp which drives the FR path to the measurement function. Also, the FS output of the sweep generator function is transformer coupled to the T195's SEND terminals for use as a level test signal.

5.3.02.06 The receive and send operations are essentially independent. Receive and send impedances are set by the In/Out Switching Function according to panel control selections made by the user.

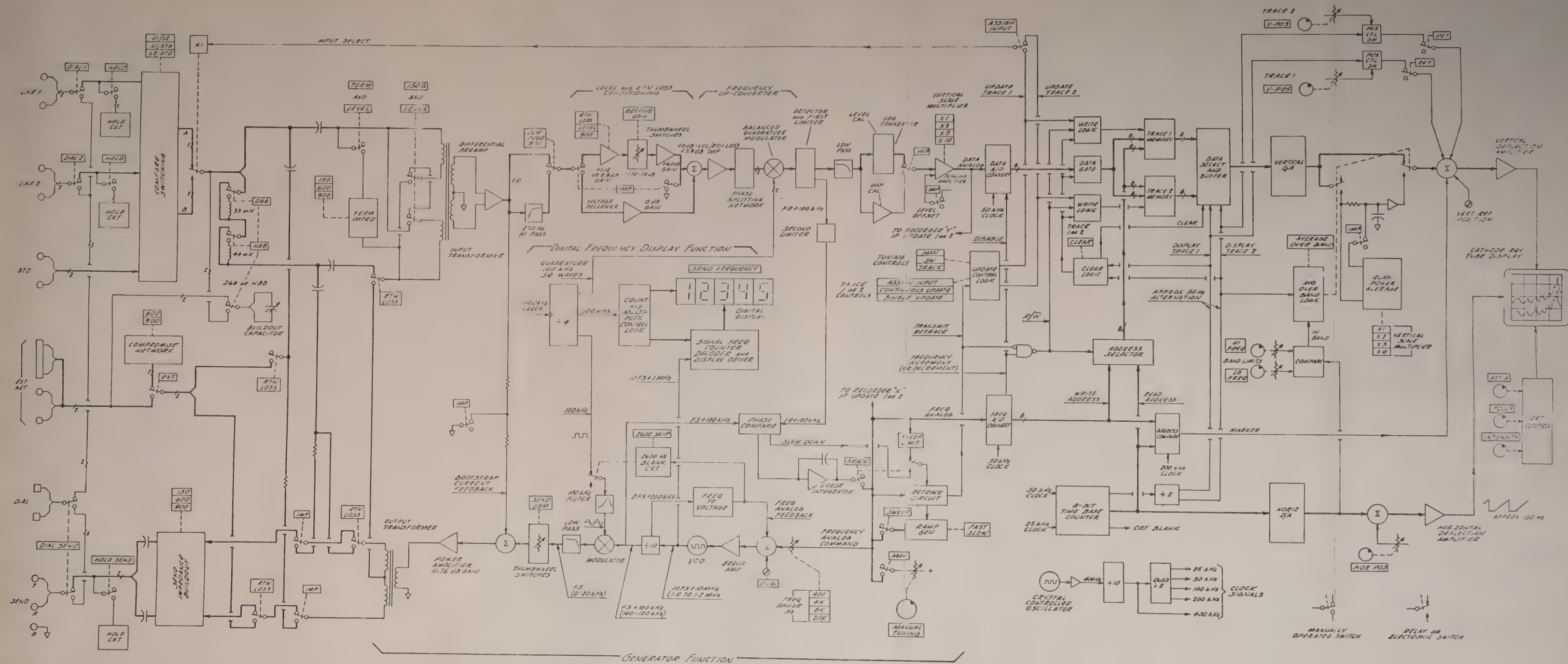
5.3.02.07 In impedance measurement configuration (Fig. 5-4), the T195 acts as an ac constant current source driving a telephone circuit or device connected to the instrument's LINE terminals. Under such conditions, the ac voltage drop which develops across the LINE terminals is proportional to the impedance of the telephone circuit or device under test.

5.3.02.08 The T195's input transformer couples the signal developed across the LINE terminals onward to the preamplifier which drives the FR path to the Measurement Function. The input transformer presents an impedance of greater than 100 k ohms to the LINE terminals and will not affect (load down) measurements on impedances up to 10 k ohms. Higher impedances can be measured if slight inaccuracy from loading by the input transformer can be tolerated.

5.3.02.09 Note that the generator's FS output is not available at the SEND terminals when using the impedance measurement configuration. Also note that the generator is actually an integral part of the impedance measurement configuration. The generator's FS signal (E1) appears across resistor R2 as $2AE1 + E2$ (where A is the gain) because the voltage drop (E2) across the impedance under test is fed back to the power amplifier's input. The feedback action maintains a constant voltage across the R2 resistors, thus insuring a constant current into the line terminals and linearizing the variation of E2 with impedance being measured.

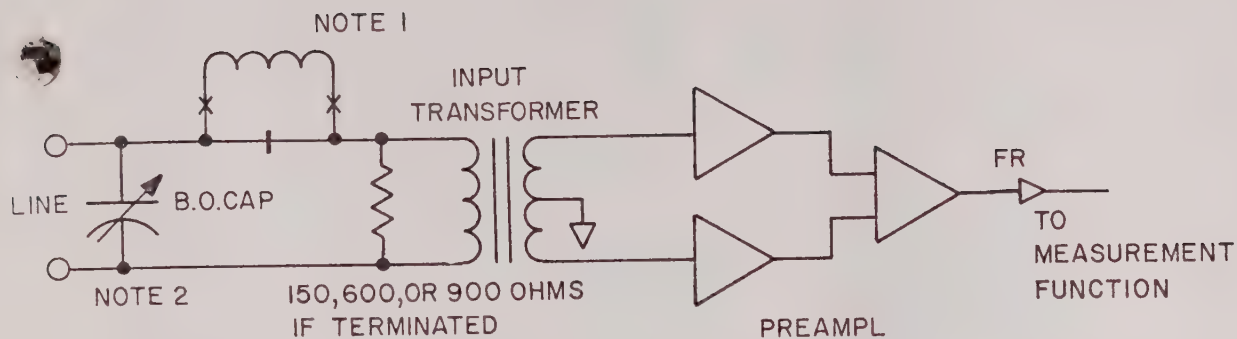
5.3.02.10 In return loss measurement configuration (Fig. 5-5), the In/Out Function uses a balanced bridge type of measuring technique. The balanced bridge network is essentially a transformer type of hybrid. An external precision network or the T195's built-in compromise network may be used as the reference arm of the balanced bridge.

NOTE: The T195's B.O. CAP can be used by itself as the reference arm of the balanced bridge in order to make capacitance measurements. And, a decade resistor can be connected to the T195 for use as the reference arm when resistance measurements are desired. See Section 5 of the Applications Manual for procedures showing such uses.



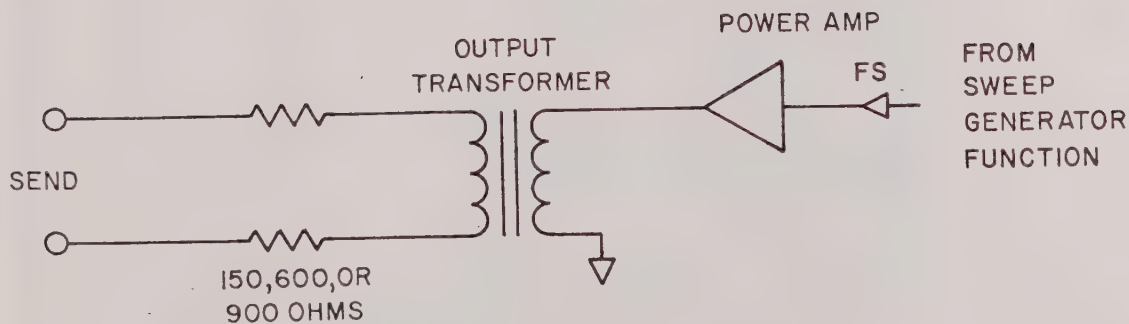
T195 Level Tracer Functional Diagram

Fig 5-2

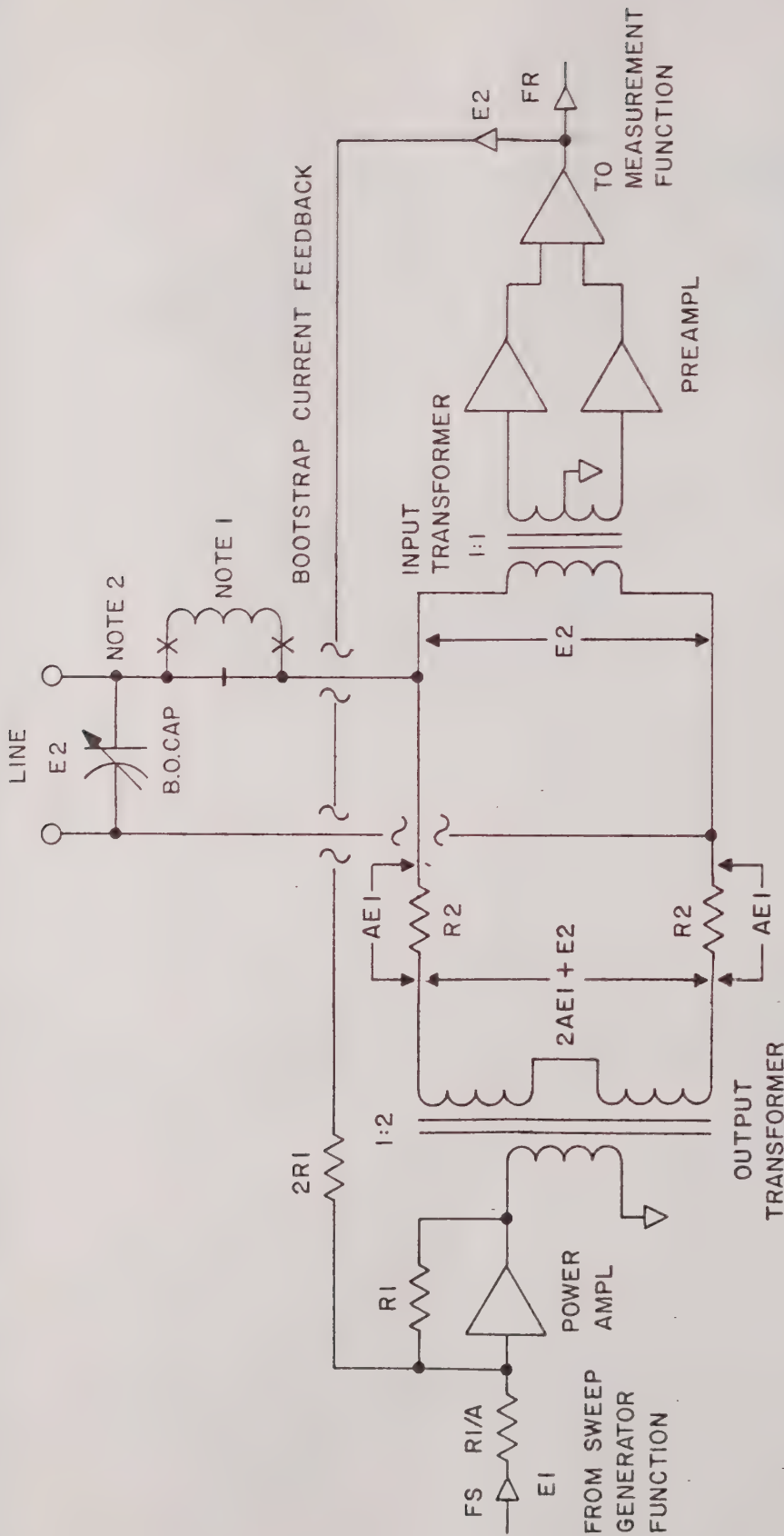


NOTES

- 1- 33mH OR 44mH INDUCTOR INSERTED WHEN D66 OR H88 IS ENGAGED.
- 2- B.O.CAP CONNECTED HERE IF D66 OR H88 IS ENGAGED.
- 3- B.O.CAP CONNECTED HERE IF D66 AND H88 ARE BOTH RELEASED.



LEVEL MEASUREMENT IN/OUT CONFIGURATION *Fig. 5-3*

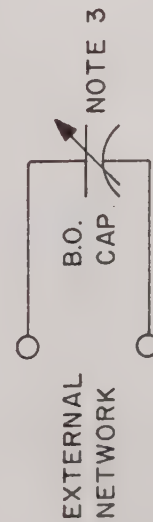


NOTES

1- 33mH OR 44mH INDUCTOR INSERTED WHEN D66 OR H88 IS ENGAGED.

2- B.O.CAP CONNECTED HERE IF D66 OR H88 IS ENGAGED.

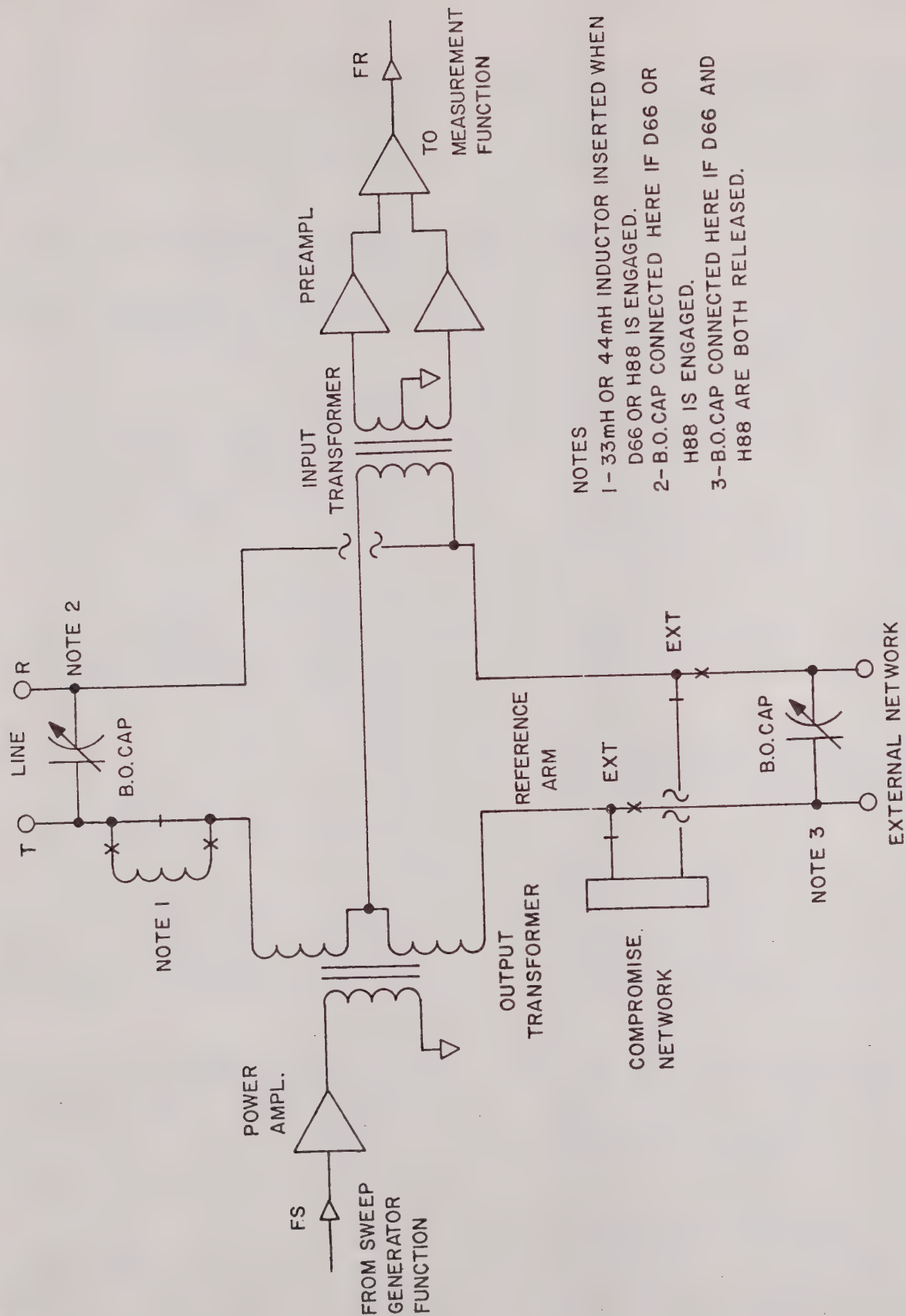
3- B.O.CAP CONNECTED HERE IF D66 AND H88 ARE BOTH RELEASED.



$$E2 = (2AE1 + E2) \frac{Z_{LINE}}{Z_{LINE} + 2R2} = AE1 \frac{Z_{LINE}}{R2}$$

IMPEDANCE MEASUREMENT IN/O - CONFIGURATION

Fig. 5-5



NOTES

- 1- 33mH OR 44mH INDUCTOR INSERTED WHEN D66 OR H88 IS ENGAGED.
- 2- B.O. CAP CONNECTED HERE IF D66 OR H88 IS ENGAGED.
- 3- B.O. CAP CONNECTED HERE IF D66 AND H88 ARE BOTH RELEASED.

RETURN LOSS MEASUREMENT IN/OUT CONFIGURATION Fig. 5-5

5.3.02.11 The balanced bridge is excited by the FS signal from the Generator Function. The preamplifier/input-transformer combination senses the degree of bridge unbalance and forwards a proportional FR signal to the Measurement Function.

NOTE: Refer to paragraph 5.4.02 for a detailed circuit theory description of the In/Out Switching Function.

5.3.03 Measurement Function

5.3.03.01 As shown on the functional diagram (Fig. 5-2), portions of the measurement function are switched to process test signals differently for impedance measurements than for level or return loss measurements. In impedance tests, a linear processing is used so the measurement result can be read from the linear ohms scale on the CRT screen. In level or return loss tests, a logarithmic processing is used so that measurement result can be read from a dB scale on the CRT screen. The impedance test processing is simpler, so it is described first.

5.3.04 Measurement Function Processing During Impedance Tests

5.3.04.01 During an impedance measurement, the FR signal from the preamplifier is passed through a voltage follower and phase splitting amplifier for application to a modulator. A pair of 100 kHz square wave signals is also applied to the modulator.

5.3.04.02 The modulator is a single sideband quadrature design. Its output contains only the frequency sum of $FR + 100$ kHz. The impedance measurement information is retained by the up conversion process, and thus the amplitude of the up converted signal is proportional to the impedance being measured.

5.3.04.03 The up converted signal is then filtered and applied to a detector/first limiter which has two outputs. One output is a detected signal proportional to the measured impedance. The other output is a signal at the $FR + 100$ kHz frequency, but voltage limited to strip off amplitude variations. Only the first output, the detected signal, is used in impedance tests. (The second output is needed only in level tests using TRACK mode as will be explained later.)

5.3.04.04 The detected signal is applied to a lowpass filter, and the filter produces a dc output voltage which is proportional to the impedance being measured. The dc voltage is then passed through an impedance calibration amplifier having a gain adjusted such that impedance traces on the CRT screen will be correctly calibrated with respect to the ohms scale on the screen.

5.3.04.05 The impedance calibration amplifier's output is then processed by a scaling amplifier having a gain which is selectable by the X1, X2, X5 and X10 VERTICAL SCALE MULTIPLIER buttons. The scaling amplifier's gain selection establishes the amplitude of measurement traces displayed on the CRT screen. For impedance measurements, the scaling amplifier is used to control trace amplitude such that four full-scale impedance ranges are available to the T195 user:

1. 0 to 1000 ohms (X1);
2. 0 to 2000 ohms (X2);
3. 0 to 5000 ohms (X5);
4. 0 to 10,000 ohms (X10).

During impedance measurements, no dc offset is applied to the scaling amplifier. Thus, the 0 (zero) ohms end of all measurement ranges is the bottom line on the CRT screen.

5.3.04.06 The scaling amplifier's output is the dc DATA-ANALOG signal forwarded to the Data Conversion, Storage and CRT Display Function.

5.3.05 Measurement Function Processing During Level Tests

5.3.05.01 During level testing, the Measurement Function's processing operations are somewhat different from those described for impedance testing. First, the level measurements are read from a scale on the CRT screen which is calibrated in dB, so logarithmic processing must be used. Second, the level measurement must be read correctly in dBm for any of the T195's three selectable impedances, so the measurement chain must be controlled according to which impedance is selected.

5.3.05.02 Consider the level measurement impedance selection situation first. Correct reading in dBm is accomplished by "normalizing" the signal voltages produced during 150 or 900 ohm level testing so they equal the voltage which would be produced by an equivalent dBm level into 600 ohms. The resulting normalized voltage is then handled as if it were produced by measurement at 600 ohms.

5.3.05.03 Normalizing the voltage from a level measurement at 150 ohms to a voltage which would be produced from an equal level measurement at 600 ohms requires that the 150 ohms measurement voltage be multiplied by $\sqrt{600/150}$, or 2. When 150 ohm impedance is selected for use in a level measurement, the doubling is accomplished within the T195's In/Out Switching Function. The input transformer's 1:1 turns ratio is changed into a 1:2 turns ratio. This increases the voltage resulting from the level measurement by 6 dB ($10 \log 600/150$) and is the required multiplication by 2.

5.3.05.04 Normalizing the voltage from a level test at 900 ohms to a voltage which would be produced from an equal level test at 600 ohms requires that the 900 ohm measurement voltage be reduced. That is, the voltage from the 900 ohm measurement must be multiplied by $\sqrt{600/900}$, or 0.816. When 900 ohm impedance is selected for a level test, the measurement function's gain is reduced by 1.76 dB ($-10 \log 600/900$) to accomplish the necessary normalization.

5.3.05.05 As shown on Figure 5-2, level measurement voltages on the FR path from the preamplifier are first passed through two conditioning amplifiers and the RECEIVE dBm attenuator. (The 900 ohm impedance has been selected by the T195's user.)

5.3.05.06 The RECEIVE dBm control is shown as an attenuator. Together with the following amplifier, it can

attenuate the measurement signal by up to 19 dB, or amplify the signal by up to 59 dB. The RECEIVE dBm control establishes the T195's overall sensitivity during level measurements and is usually set to position the measurement trace somewhere near the 0 dB line on the CRT screen.

5.3.05.07 After processing by the conditioning components, the level measurement signal is up converted by the modulator to produce the frequency sum of $FR + 100$ kHz at the modulator's output. As described previously, the up conversion process retains the level measurement information, and thus the amplitude of the up converted signal is proportional to the level being measured.

5.3.05.08 The detector/first limiter's detected output is filtered to produce a dc signal proportional to the level being measured. The detector/first limiter's other output is limited again to completely remove all amplitude variations and produce a square wave having the $FR + 100$ kHz frequency. This signal is forwarded to the Generator Function where it enables the T195 to lock-on and follow the frequency of an incoming test signal if the TRACK mode is selected.

5.3.05.09 The detected dc signal, proportional to measured level, is applied to a circuit having a gain characteristic which is logarithmic with respect to its input voltage. The log converter applies more gain to weak signals and less gain to strong signals. Thus, its output is "compressed" into a total amplitude range considerably smaller than the amplitude range over which its input signal may vary.

5.3.05.10 The log converter has a 40 dB input dynamic range. It can properly handle, for display on the CRT screen, input signals from 10 dB above to 30 dB below the setting of the RECEIVE dBm control. The overall measurement range of the T195 is 108 dB from +19 dBm to -89 dBm.

5.3.05.11 The log converter's output is a dc voltage proportional to the level, in dB, being measured. The converter is set to produce zero output for the input signal level (depending on RECEIVE dBm setting), which corresponds to the zero dB reference line on the CRT screen, and its output scale factor (volts/dB) is adjusted for correct calibration with respect to the other lines.

5.3.05.12 The log converter's output is then processed by the scaling amplifier which imposes gain set by the X1, X2, X5 and X10 VERTICAL SCALE MULTIPLIER buttons. For level measurements, the scaling amplifier controls trace amplitude such that four full-scale ranges are available:

1. -3 to +1 dB (X1);
2. -6 to +2 dB (X2);
3. -15 to +5 dB (X5);
4. -30 to +10 dB (X10).

These ranges are read with respect to the setting of the RECEIVE dBm control.

5.3.05.13 Also during level measurements, a dc offset is applied to the scaling amplifier. This places the displayed trace on the screen's 0 dB line for a measured level which equals the RECEIVE dBm control setting. The scaling amplifier's output is the DATA-ANALOG signal forwarded to the Data Conversion, Storage, and CRT Display Function.

5.3.06 Measurement Function Processing During Return Loss Tests

5.3.06.01 During return loss testing, the Measurement Function's processing operations are virtually identical to those described for level measurements. The only difference is in normalization imposed on the FR measurement signal. For return loss measurements, the first conditioning amplifier's gain is always reduced by 1.76 dB, the same amount of gain reduction used for level measurements into 900 ohms. Otherwise processing is the same as for level measurements.

NOTE: See paragraph 5.4.07 for a detailed circuit theory description of the measurement function.

5.3.07 Data Conversion, Storage, and CRT Display Function

5.3.07.01 The Data Conversion, Storage and Cathode-Ray-Tube Display Function receives, processes and displays data from the DATA-ANALOG and FREQUENCY-ANALOG inputs as shown on the functional diagram, Figure 5-2. It also provides timing information for other functions in the T195.

5.3.07.02 All critical timing in the T195 originates in a precise 4 MHz crystal-controlled oscillator. The oscillator output is frequency-divided by ten to provide a 400 kHz clock used in the digital frequency display function. It is then further divided to provide clock signals at 200, 100, 50 and 25 kHz for use in various parts of the Data Conversion, Storage and CRT Display Function.

5.3.07.03 DATA-ANALOG is a dc signal carrying the processed result of a measurement in progress. FREQUENCY-ANALOG is a dc signal which indicates the frequency to which the generator function is presently tuned. Both signals are presented to A/D converters in the Conversion, Storage and CRT Display Function. The DATA-ANALOG signal is sampled and converted to digital form for presentation to the DATA-DIGITAL inputs of the two trace memories. The FREQUENCY-ANALOG signal is also sampled and converted to digital form to become the WRITE ADDRESS information shown on Figure 5-2.

5.3.07.04 Whenever a measurement data sample is to be written into a trace memory, a logic zero on the R/W control signal line instructs the address selector to pass the WRITE ADDRESS on to the two memories. Thus, measurement data samples are always written into the memories at addresses corresponding to the test frequencies at which the measurement samples were taken. For example, if the T195 is sweeping its test frequency, the FREQUENCY-ANALOG signal will be increasing as the sweep progresses. This causes the WRITE ADDRESS to also increment upward so successive DATA-DIGITAL samples

are stored at successively higher-numbered memory address locations.

5.3.07.05 Each memory has 256 storage locations. If the T195 is instructed to make a SLOW frequency sweep, then five seconds are required for the measurement and for storage of its data samples into the 256 memory locations. A data sample write-in occurs about once every 20 milliseconds under these conditions.

5.3.07.06 Simultaneously, and at all times, the time base counter shown on Figure 5-2 is operating to increment the READ ADDRESS count. A full count up through 256 successive READ ADDRESSES is performed in 10.56 milliseconds. The time base counter is then reset to zero and, begins again to count up toward 255. New READ ADDRESSES are thus continuously produced, at a rate of one new READ ADDRESS every 41 microseconds.

5.3.07.07 Each successive READ ADDRESS is converted to an analog voltage by the horizontal D/A converter. Thus the converter's HORIZ output signal is an increasing ramp (sawtooth) waveform. The HORIZ signal is processed by the horizontal deflection amplifier to create the horizontal deflection signal which drives the CRT's sweep along the X axis calibrated in terms of frequency.

5.3.07.08 The successive READ ADDRESSES are also gated through the address selector under control of the R/W signal. Thus, the READ ADDRESSES are passed to the two trace memories at all times except when data is to be written.

5.3.07.09 As the successive READ ADDRESSES are presented to the memories, the measurement data samples at those address locations are read from the memories. The read buffer and memory data selector passes the successive measurement data samples from one memory or the other onward to the vertical D/A converter. The read buffer and memory data selector is told which memory's data to pass according to the status of the DISPLAY TRACE 1 and DISPLAY TRACE 2 control signals shown on Figure 5-2.

5.3.07.10 The vertical D/A converter changes the measurement data samples from digital form back into analog form. The resulting analog signal is then processed through the vertical deflection amplifier to create the vertical deflection signal which drives the CRT's Y axis. The Y axis scales are calibrated in terms of both ohms and dB for presentation of the measurement data from impedance, level and return loss testing.

5.3.07.11 It should be noted that the measurement data write-in and read-out operations just described are performed independently and asynchronously at different rates. The write-in operations occur at a much slower rate than the read-out operations. This allows multiple read-outs to be performed between each single write-in operation. The result is a fast, flicker-free and continuous refreshing of the information displayed on the CRT traces independent of whether or not any new measurement data is being acquired by the T195.

5.3.07.12 In actual operation the contents of the two trace memories are read out alternately at a 50 Hz rate. This permits one vertical D/A converter to process the

data from both memories, one after the other. The result is a dual-trace presentation on the screen.

5.3.07.13 The TRANSMIT RETRACE signal shown on Figure 5-2 informs the update control logic when each measurement frequency sweep has been completed. Upon each sweep completion (in SWEEP tuning mode), the control logic examines the status of the ASSIGN INPUT, CONTINUOUS UPDATE, and SINGLE UPDATE controls to decide what should be done on the next measurement frequency sweep. If continuous updating is selected for either or both of the traces, then new measurement data samples will be written into the correct memory (or memories) during the next measurement sweep.

5.3.07.14 If continuous updating is not selected, then measurement data presently in the memories will be retained until a future sweep when either a CONTINUOUS or SINGLE update is requested by the T195's user. Old data retained in the memories is still displayed on the screen, however, because the READ ADDRESSING continues without regard to the status of the write-in updating operations.

5.3.07.15 Either memory can be cleared at any time by use of the front panel CLEAR pushbuttons.

5.3.07.16 It should be emphasized that there is complete flexibility in updating either or both of the memories, and also in the assignment of a measurement input (LINE-1, LINE-2, STD) to either memory. For example, both memories (and their CRT traces) may be assigned to a single input. Or, each memory (and its trace) can be assigned to a different input. Also, the input/memory assignments may be reversed. Memory updating can be requested for only one generator-frequency sweep or on each successive sweep, on either trace in any combination. Refer to sections 4.5 to 4.7 for a complete description of input/memory assignments.

5.3.07.17 Note from Figure 5-2 that the vertical deflection amplifier's input is actually the sum of signals and voltages from several sources. The principal vertical deflection input is, of course, the measurement information signal from the vertical D/A converter. However, if the AVERAGE OVER BAND control is selected the D/A's output is diverted through an averaging circuit before application to the vertical deflection amplifier's input.

5.3.07.18 Actually, the diversion through the averaging circuit occurs only when the HORIZ (ramp) signal lies between two voltages which correspond to the two frequencies set on the LOW FREQ and HIGH FREQ BAND LIMITS controls. Outside the two frequency limits, the measurement information is passed directly to the vertical deflection amplifier without diversion through the averaging circuit. Also, the diversion occurs only when data from memory 2 is being read, since the AVERAGE OVER BAND function is provided only on TRACE 2.

5.3.07.19 During impedance measurement the AVERAGE OVER BAND uses a simple R-C circuit to obtain the linear average of impedance over the selected band. During return loss (or level) measurement, the desired reading is the average power over the band, expressed in dB, and not the average dB level. Therefore,

uring these measurements, a non-linear "quasi power-average" circuit is switched in to give a reading which is a compromise between average and peak dB level and which approximates the average power level expressed in dB. The characteristics of this circuit depend on the VERTICAL SCALE MULTIPLIER chosen.

5.3.07.20 The TRACE 1 V-POS and TRACE 2 V-POS controls furnish dc levels which are summed with the measurement signal to position the two traces on the screen as desired. These position controls are disabled when the associated toggle switches are in the REF position. Also, each is disabled when the other trace is being displayed.

5.3.07.21 Finally, a marker signal may also be summed with the measurement information for presentation on the two displayed traces. If the FREQ MARK control is selected, then the marker control block shown on Figure 5-1 injects a brief burst of 200 kHz signal whenever the WRITE and READ ADDRESSES are equal. This processing makes a marker "pip" appear on both traces at the present frequency position which corresponds to the T195's present measurement tuning. If a frequency sweep is in progress, the marker pip moves slowly across the displayed traces in synchronism with the generator's tuning change.

5.3.07.22 The X-Y recorder output terminals on the T195 are supplying an X-Y plotter with dc signals proportional to the present measurement result and the present measurement frequency tuning. The DATA-ANALOG and FREQ-ANALOG signals are presented to the X-Y outputs, to accomplish this function, whenever either trace is being updated.

NOTE: See paragraph 5.4.13 for a detailed circuit theory description of the Data Conversion, Storage, and Cathode-Ray-Tube Display function.

5.3.08 Generator Function

5.3.08.01 In the send-frequency signal generator, a voltage-controlled oscillator (VCO), with analog control circuits, produces a signal in the frequency range of 1.0 to 1.2 MHz (10 FS + 1 MHz). This signal is frequency divided by 10, and the resulting square wave at 100 to 120 kHz (FS + 100 kHz) is combined in a balanced modulator with a precision 100 kHz sine wave. The difference frequency produced in the modulator, after low-pass filtering, is the send frequency (FS), at zero to 20 kHz.

5.3.08.02 At the output of the lowpass filter, the FS signal has an amplitude of 0.775 Vrms (or 0 dBm into 600 ohms). This signal is then applied to the SEND attenuator and a power amplifier for transmission to the In/Out Switching Function.

5.3.08.03 The generator frequency is controlled by a dc FREQUENCY ANALOG COMMAND voltage. In MAN (manual) tuning mode, the FREQUENCY ANALOG COMMAND is derived directly from the panel mounted MANUAL TUNING control. In SW (sweep) mode, the FREQ. ANALOG COMMAND is the output of the sawtooth (ramp) waveform generator. In TRACK mode, when the T195 is receiving an incoming signal, the up converted and voltage-limited receive signal, FR + 100

kHz, is phase-compared with the generator FS + 100 kHz signal, and the error at the phase comparator output is integrated to produce the FREQ ANALOG COMMAND.

5.3.08.04 A TRANSMIT RETRACE signal is generated when the FREQ ANALOG COMMAND reaches the upper limit of its range. This signal is used in the UPDATE CONTROL LOGIC as previously described, and also resets the ramp generator to complete the sawtooth waveform in SW mode.

5.3.08.05 The FREQ ANALOG COMMAND has one voltage range for all four sweep ranges. It is therefore divided down in the FREQ RANGE Hz control to produce a common volts/hertz rate for all ranges before being used as the control input to the generator frequency control loop.

5.3.08.06 The FS + 100 kHz signal is converted, in the FREQ-TO-VOLTAGE circuit, to a FREQ ANALOG FEEDBACK signal. The positive voltage FREQ ANALOG COMMAND, after division by the FREQ RANGE Hz control is summed with the negative voltage FREQ ANALOG FEEDBACK, and the resulting error voltage is the voltage input to the VCO.

5.3.08.07 If the T195's user selects the 2600 SKIP control, the generator function will stop transmitting an FS signal anytime tuning enters a band between 2450 and 2750 Hz. To accomplish this, the 2600 Hz blank circuit shown on Figure 5-2 cuts off the 100 kHz reference signal from the modulator anytime the FREQ ANALOG FEEDBACK voltage indicates that tuning is within the 2450 to 2750 Hz band.

NOTE: Refer to paragraph 5.4.24 for detailed circuit theory of the Generator Function.

5.3.09 Digital Frequency Display Function

5.3.09.01 The Digital Frequency Display Function measures and displays the frequency (FS) of the generator output. The precision 400 kHz clock is used as the standard of measurement.

5.3.09.02 The clock frequency is first divided by four. Two quadrature 100 kHz outputs from the divider are used in the receive signal up-converter. Another output provides the 100 kHz reference for the send-frequency signal generator.

5.3.09.03 Further frequency division and logic circuits, in the COUNT & MULTIPLY CONTROL LOGIC block provide the sampling time interval and control signals for the SIGNAL FREQUENCY COUNTER, and for multiplexing the digits in the digital display.

5.3.09.04 The signal actually counted by the signal frequency counter is the 10 FS + 1 MHz signal from the generator function. The frequency counter samples this signal for 100 milliseconds (0.1 second), an operation which effectively divides the signal by 10. (N counts/sec for 0.1 sec gives a count of N/10.)

5.3.09.05 During the 0.1 second sampling period the signal is presented to a counting chain comprising five decade counter stages. The chain is too "short" to hold the

full count during the sample period, and it permits the count of 100 kHz to overflow. This, in effect, automatically subtracts 100 kHz from the signal, and leaves only the FS signal count still in the counter stages which drive the SEND FREQUENCY readout.

5.3.09.06 Consider the following example which illustrates the operations involved in counting the signal from the Generator Function. Assume that the sweep generator's FS signal is 250 Hz,

then, $10FS = 2,500 \text{ Hz}$,

and $10FS + 1 \text{ MHz} = 1,002,500 \text{ Hz}$.

The sweep generator thus presents a signal frequency of 1,002,500 Hz to the Digital Frequency Display Function on the $10 FS + 1 \text{ MHz}$ path. When this frequency is counted for 0.1 second, the count will reach 100,250 effectively a division by 10. Since there are only 5 stages in the counting chain, the first 100,000 counts will overflow. This leaves only the last 250 counts of the sample still in the counting chain. The chain thus presents the number 250 to the SEND FREQUENCY digital display and this shows the frequency of the original FS signal in Hz.

5.3.09.07 This counting method permits fast updating of the SEND FREQUENCY readout, at a rate of about 8 updates per second. Since the $10 FS + 1 \text{ MHz}$ signal can range only between 1.0 and 1.2 MHz, the method cannot result in an ambiguous display on the SEND FREQUENCY readout.

5.3.09.08 The Digital Frequency Display Function contains control circuits which blank out leading zeros on the SEND FREQUENCY display.

NOTE: See paragraph 5.3.29 for detailed circuit theory of the Digital Frequency Display Function.

5.4 Schematic Diagram Description

5.4.01 The remainder of this section provides detailed descriptions of the various electronic circuits which comprise the T195's major functions. Figure 5-6 is a simplified schematic diagram which may be followed as an aid to understanding the descriptions. The circuits are described function-by-function for ease in referencing back to the block and functional descriptions presented previously in this section.

5.4.02 In/Out Switching Function: Detailed Circuit Theory

5.4.02.01 The In/Out Switching Function comprises:

1. Input and power amplifier board (0195-02-014);
2. Part of preamplifier and display scaling board (0195-02-015). See paragraph 5.3.02 for an overall description of the function's operations. Refer to the following paragraphs for information on the Function's special circuits.

5.4.03 Hold Circuits

5.4.03.01 Three electronic hold circuits are located on input and power amplifier board 014. Figure 5-7 is the schematic diagram for one typical hold circuit.

5.4.03.02 The hold circuit is essentially a form of dc current regulator. It establishes a dc holding current set by the voltage across tip and ring leads presented to it. When any ac signals are presented to the hold circuit, it acts to resist changes in the constant dc holding current. Thus, the hold circuit appears to a telephone tip/ring pair as a fairly low dc resistance, but at the same time, as a very high ac impedance.

5.4.03.03 The diode bridge (CR1,2,3,4) steers voltage/current correctly for operation of the hold circuit regardless of tip and ring polarities. The current through darlington transistor pair Q2-Q3 is determined by the voltage at the base of Q2 (with respect to the negative voltage end of the diode bridge) and the value of resistor R3. When the T195 is used at the end of a line with high loop resistance, the dc voltage will be low due to drop in the loop. In this case, the voltage at Q2 base, and hence the current, is determined by voltage division in the resistor network R1, R2, R4, R5 and R6. It is held constant by C1. The dc resistance of the overall circuit is about 200 ohms, and the ac impedance is very high.

5.4.03.04 On shorter loops, the voltage and current increase until Q1 conducts, limiting further increase at Q2 base. The overall circuit now approximates a constant-current sink at about 35 mA dc, while the ac impedance remains very high.

5.4.03.05 Varistor RV1, along with diode CR5 and resistor R3, protect the HOLD circuit from lightning-induced voltage spikes.

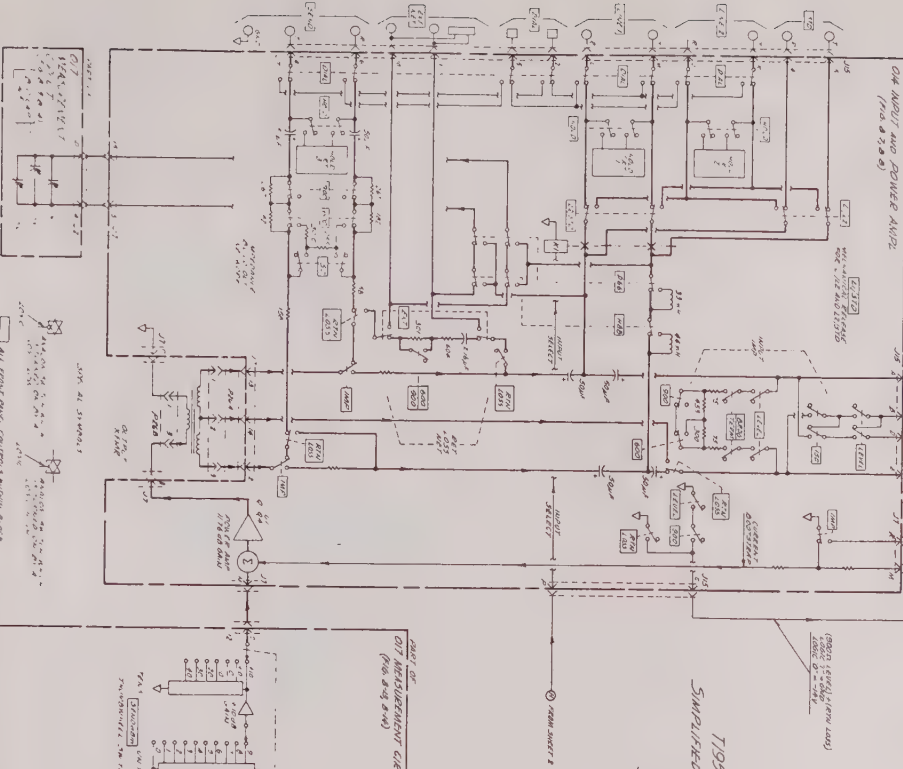
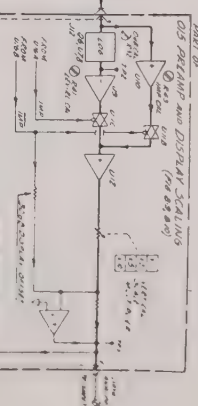
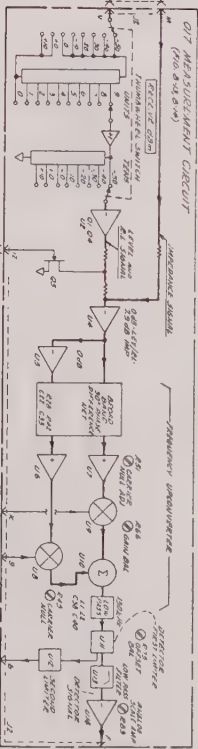
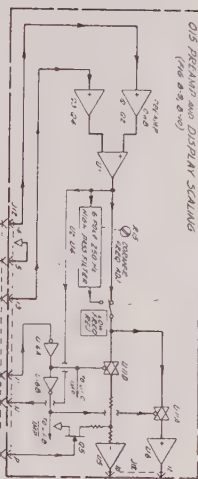
5.4.04 Preamplifier

5.4.04.01 The preamplifier is shown on Figure 5-6 in simplified form. Figure 8-11 shows the full detail. The preamplifier comprises two compound emitter followers (Q1/Q2 and Q3/Q4 on board 015) driving a differential-input amplifier U1. This circuit arrangement presents a very high balanced load impedance to the split secondary input transformer. The secondary configuration and balanced preamplifier design results in cancellation of capacitively coupled common mode input noise signals, producing an input circuit with good longitudinal balance characteristics. The gain of the entire preamplifier is 1, or 0 dB, in order to pass high amplitude +20 dBm (900) signals without distortion.

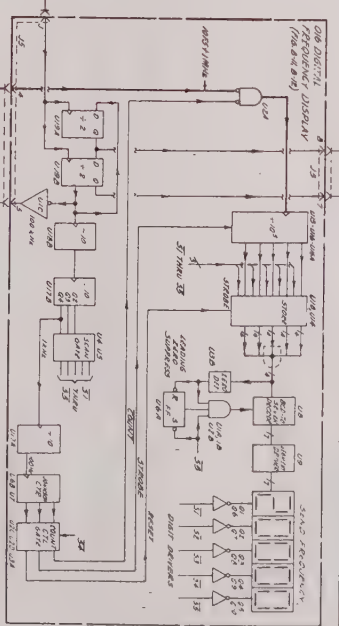
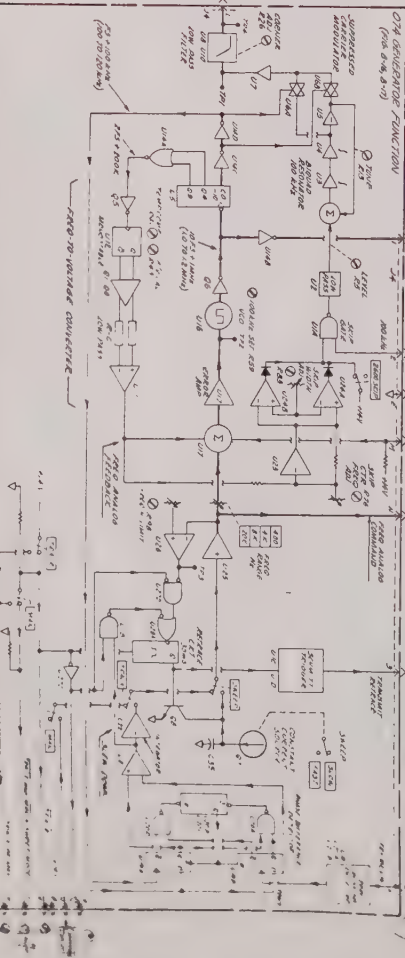
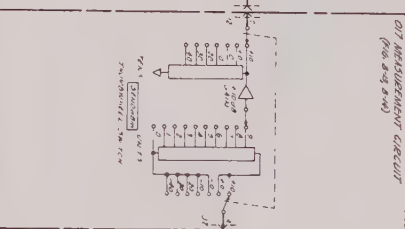
NOTE: The preamplifier monitors signals from the T195's input transformer. This transformer normally has a 1:1 turns ratio. Thus, voltage gain from transformer input to preamplifier output is normally 0 dB. However, when performing level tests using 150 ohms input impedance, the transformer turns ratio is switched to 1:2. In this case the voltage gain from transformer input to preamplifier output is +6 dB.

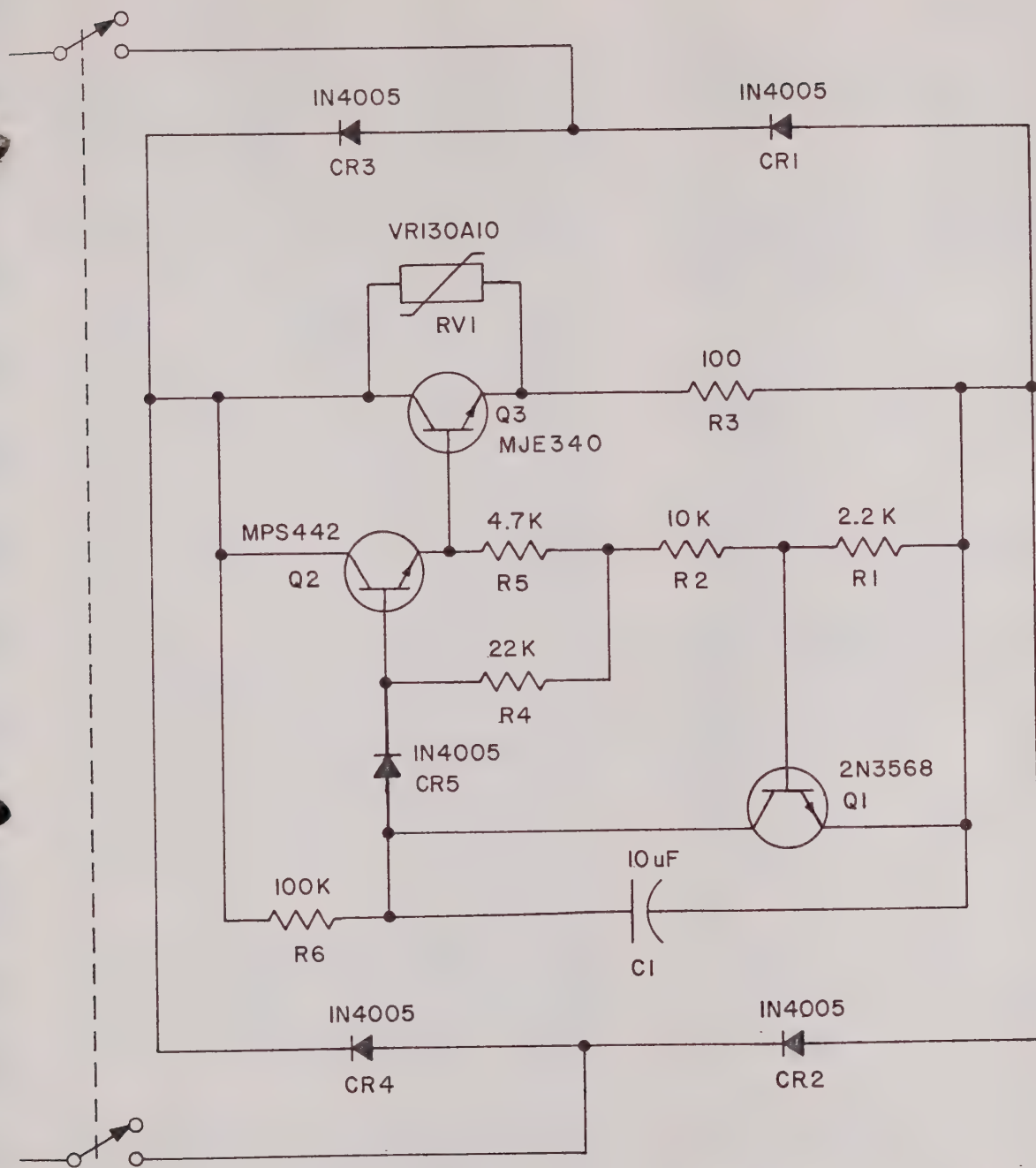
5.4.05 Power Amplifier

5.4.05.01 See Figure 8-8 for schematic details of the power amplifier. The power amplifier comprises U1 and Q1 through Q4 (board 014). It supplies approximately 11.76 dB of voltage gain for the FS signal output of the sweep generator.



7195 LEVEL TRIGGER
Fig 5.6
SHEET 1 OF 2





HOLD

NOTES

- 1- FOR HOLD CIRCUIT 1, ADD 100 TO REFERENCE DESIGNATIONS.
- 2- FOR HOLD CIRCUIT 2, ADD 200 TO REFERENCE DESIGNATIONS.
- 3- FOR HOLD CIRCUIT 3, ADD 300 TO REFERENCE DESIGNATIONS.

HOLD CIRCUIT SCHEMATIC

Fig. 5-7

5.4.05.02 U1 is an operational amplifier in series with a complementary pair of emitter followers (Q1/Q2 and Q3/Q4). Feedback resistor R10 sets the overall voltage gain.

5.4.06 Output Signal Levels

5.4.06.01 The power amplifier is one component in the complete path which establishes the T195's output signal level. The path is shown in Figure 5-8. The complete path includes the SEND dBm attenuator, the power amplifier, the output transformer, the impedance build-out network, and the load.

5.4.06.02 Figure 5-8 shows the output signal levels at various key points along the complete path, for the three selectable output impedance values, with the SEND dBm control set at ± 0 dBm. Note that the SEND dBm attenuator actually imposes 10 dB more loss than the setting which appears on the thumbwheels. The power amplifier restores this 10 dB and adds an additional 1.76 dB for a total of 11.76 dB voltage gain. The additional 1.76 dB of gain effectively changes the voltage to represent a given power level into 900 ohms instead of the same power level into 600 ohms.

5.4.06.03 The output transformer doubles the signal voltage to produce the required open-circuit output voltage for 900 ohm SEND IMPEDANCE. The impedance buildout network then determines both the impedance and the open circuit voltage for each selected SEND IMPEDANCE. In the case of 900 ohm, this is simply a series resistance of 425 ohms in each side of the line which, added to a dynamic output impedance of approximately 50 ohms at the transformer secondary, gives a 900 ohm total. In the case of 600 and 150 ohm output impedance, the buildout network includes both series and shunt elements.

5.4.07 Measurement Function: Detailed Circuit Theory

5.4.07.01 The Measurement Function comprises:

1. Part of preamplifier and display scaling board (0195-02-015);
2. Measurement circuit board (0195-02-017).

See paragraph 5.3.03 for an overall description of the function's operations. Refer to the following paragraphs for detailed circuit theory.

5.4.08 Measurement Input Signal Conditioning

5.4.08.01 The FR signal from the preamplifier can be switched along either of two different paths to the actual measurement circuits. One path is direct. The other path is through a highpass filter designed to remove low frequency noise such as 60 Hz hum from the input under test. The highpass filter U2, U3, U4 (015 board) is a three-stage, stagger-tuned, active filter network. Each stage is a unity gain, multiple feedback operational circuit which supplies two filter poles. Thus, the overall filter has 6 poles. Its cutoff frequency is 250 Hz, slope 36 dB per octave.

5.4.08.02 Measurement signals from the direct or the filter path are selected by the LOW FREQ REJ switch for

application to the actual measuring circuits. During impedance tests, analog transmission gate U11A (015 board) is ON and gate U11D is OFF. Thus, input signals are directed to amplifier U6. This amplifier is simply a buffer which imposes no gain or loss. The amplifier's output is the IMP signal path to the 017 measurement board.

5.4.08.03 During level and return loss tests, transmission gate U11A is OFF and gate U11D is ON. This applies measurement signals from the preamplifier to a LEVEL/RTN LOSS conditioning path.

5.4.08.04 The first stage along the LEVEL/RTN LOSS conditioning path is amplifier U5/Q5 (015 board) which scales the measurement signals. This amplifier's gain is set such that a 0 dBm measured level will appear to the T195's log amp as a 1 volt signal. During level measurements with 150 and 600 ohm impedances, amplifier U5/Q5 has a voltage gain of about 2.88 dB. However, for level measurements at 900 ohms, and for all return loss measurements, the voltage gain of amplifier U5/Q5 is reduced by 1.76 dB. This provides "normalization" from 900 to 600 ohm signal voltage as described in paragraph 5.3.05.04. The gain switching is accomplished as described in the following paragraph.

5.4.08.05 Normally, FET Q5 is non-conducting and the ratio of feedback resistance (resistor R22) to input resistance (resistors R20 and R21) sets the gain at 2.87 dB. During return loss measurement or a 900 ohm level measurement the control signal turns FET Q5 ON to insert resistor R23. This diverts part of U5's input signal drive current from its inverting input to ground. Since stage U5 output signal amplitude is related to input signal current times R22, gain of the stage is reduced by 1.76 dB by diverting a proper proportion of this current through R23 and Q5 to ground.

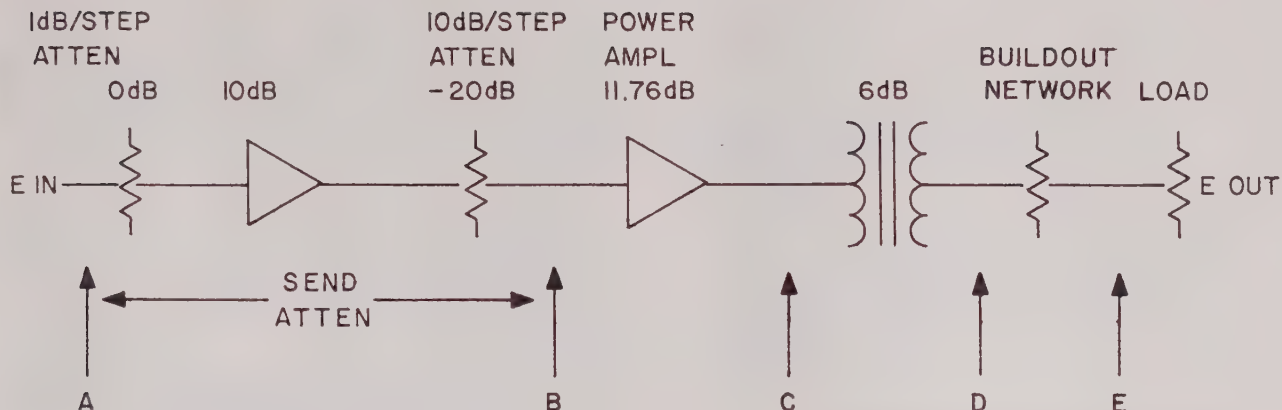
5.4.08.06 The output of the U5/Q5 (015 board) stage is the LVL/RTN LOSS signal forwarded to the 017 measurement board. On the 017 measurement board, this signal is applied to two attenuators controlled by the RECEIVE dBm thumbwheels. The two attenuators are isolated by voltage follower U1 (017 board). The output of the two attenuators is boosted 60 dB by amplifiers Q1-Q4 and U2 (017 board).

5.4.08.07 The Q1-Q4/U2 amplifier chain imposes 60 dB gain. Therefore, the attenuators are required to actually reduce the signal by 60 dB more than the setting which appears on the RECEIVE dBm thumbwheels. For example, for a RECEIVE dBm setting of -15 dBm, the attenuators reduce the signal by 45 dB and the amplifiers boost the signal by 60 dB. The result is an overall gain of 15 dB (negative attenuation on RECEIVE dBm means a positive gain.)

5.4.08.08 The attenuation capabilities permit a T195 user to set the instrument's overall sensitivity in level and return loss measurements. The user applies attenuation (or gain) as needed to bring a measurement signal within the amplitude range which can be handled by the instrument's logarithmic amplifier. The log amplifier is described in later paragraphs.

SEND dBm SET
AT -00 dB

SEND IMPEDANCE
150,600,900



SEND IMPEDANCE	A INPUT LEVEL	B LEVEL AT ATTEN OUT	C LEVEL AT AMP OUT	D LEVEL AT BUILDOUT NETWORK INPUT	LOSS IN BUILDOUT NETWORK WITH MATCHING LOAD	E OUTPUT LEVEL
900	0dB (600 OHMS)	-10dB (600 OHMS)	0dB (900 OHMS)	6dB (900 OHMS)	6dB	0dB (900 OHMS)
	.7746V	.245V	.949V	1.90V		.949V
600	0dB (600 OHMS)	-10dB (600 OHMS)	0dB (900 OHMS)	6dB (900 OHMS)	7.76dB	0dB (600 OHMS)
	.7746V	.245V	.949V	1.90V		.7746V
150	0dB (600 OHMS)	-10dB (600 OHMS)	0dB (900 OHMS)	6dB (900 OHMS)	13.78dB	0dB (150 OHMS)
	.7746V	.245V	.949V	1.90V		.387V

NOTES: THE VOLTAGE VALUES ARE RMS VALUES.

LOAD IMPEDANCE MATCHING SEND IMPEDANCE IS ASSUMED.

OUTPUT SIGNAL LEVELS

Fig. 5-8

5.4.08.09 Amplifier U4 (017 board) receives its input signal from either the impedance or the LEVEL/RTN LOSS conditioning path, depending on what type of measurement is being made. During level and return loss tests, FET switch Q5 (017 board) is off, and the gain of amplifier U4, referred to the level/return loss input, is 0 dB. During an impedance test, FET switch Q5 is on, insuring that no signal from the level/return loss path can reach amplifier U4. The amplifier's gain, referred to the impedance input, is about 7.9 dB. This gain scales the impedance measurements such that a 10 kohm impedance will result in a 7 volt signal after detection in the measurement function. (Scaling for level and return loss tests is done by amplifier U5/Q5 on the 015 board as described previously.)

5.4.09 Measure Frequency Translation (up conversion)

5.4.09.01 After processing through amplifier U4 (017 board), all test signals are up converted to a higher frequency band in a frequency translation operation. Up conversion is used because:

1. It raises test signals to higher frequencies where detection and filtering are simple and fast, significantly reducing delays which would otherwise affect the T195's measurement display;
2. It reduces the percentage frequency band over which lock-on and tracking must operate when using TRACK mode.

5.4.09.02 The test signals are translated upward onto a 100 kHz carrier using a single sideband suppressed carrier modulator employing a phase shifting technique. This technique uses two double-balanced modulators having their carrier inputs and their signal inputs both in quadrature. In effect, one modulator multiplies sine components, and the other multiplies cosine components. Because of phase relationships at the modulator outputs, the lower sideband is cancelled out when the modulator output signals are summed. The resulting output is the input frequency plus 100 kHz (FR + 100 kHz). Figure 5-9 is a block diagram of the frequency translation operation which shows the various signals and trigonometric relationships involved.

5.4.09.03 The measurement input signal requires complex linear phase shifting filters to produce the two quadrature components for input to the balanced-modulators. The phase shifting network is a computer-designed set of filters (R28-R34/C22-C27 and R35-R42/C28-C33). Each filter phase shifts the measurement input signal through increasing delays with increasing frequency. However, one filter output always lags the other filter output by 90 degrees across the measurement input band of 20 Hz to 20 kHz.

5.4.09.04 The two 100 kHz carrier signals supplied to the modulators in quadrature are received from the frequency counter board (0195-02-016). A digital counter U19A/U19B on the 016 board divides a 400 kHz clock signal to produce the two 100 kHz signals having proper quadrature phase relationship.

5.4.09.05 The balanced modulators U8 and U9 (017 board) are integrated circuit devices. Each modulator provides at its output the product of the input signal voltage and the carrier switching function. Even though the carrier is a square wave with a full complement of odd harmonics, the lowest unwanted upper sideband frequency is FR + 300 kHz, which is easily removed by filtering.

5.4.09.06 Amplifier U10 (017 board) sums the output signals from the two modulators. Because of the phasing relationships this results in a signal containing only the sum frequencies. Difference frequencies are cancelled. Amplitude information contained in the input signal is preserved.

5.4.09.07 Odd harmonics of the square-wave 100 kHz carrier frequency (3rd, 5th, 7th, etc.) cause modulation products near 300 kHz and higher. The L.C. Filter (L1-L2/C38-C40) designed for a sharp cutoff beyond 130 kHz rejects these frequencies.

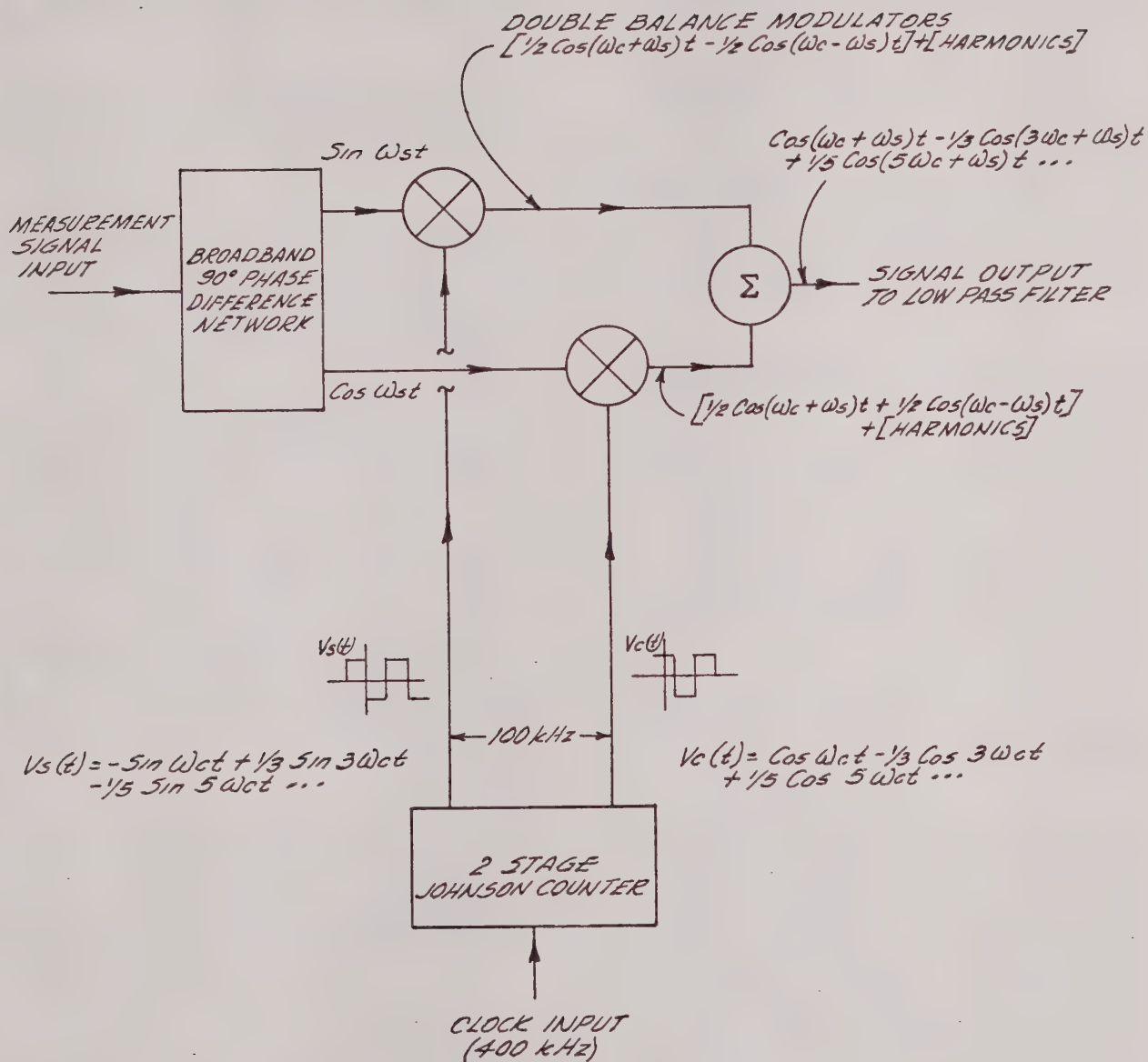
5.4.10 Measurement Signal Detection and Limiting

5.4.10.01 The sum frequency output of amplifier U10 (017 board) has an amplitude which is proportional to the level, return loss, or impedance being measured. This signal is applied to detector/first limiter U11 (017 board). The detector/first limiter has two outputs. For the detector output, a diode and its filter are made the feedback circuit for U11. Each time the input signal crosses zero, the output of U11 swings rapidly through the diode threshold 0.6V region at full open loop gain with no feedback resulting until the threshold is crossed. The feedback voltage, and hence, the detector output faithfully reproduces one half cycle of the input waveform with no apparent diode threshold to overcome. The full diode threshold plus signal excursion exists at U11 output pin 6 even though it does not appear in the detected output. This feature is used for the first limiter output function. An additional diode and filter is added (CR5, R73, C42) to make the limiter function symmetrical.

5.4.10.02 The detected signal from U11 passes through active low pass filter U13 (017 board) which removes ripple and produces a dc output proportional to the parameter being measured. Filter U13 is a unity-gain, multiple-feedback active network with a cutoff frequency of approximately 50 Hz.

5.4.10.03 The output of filter U13 is dc-coupled to analog scale amplifier U14 (017 board). The gain of U14 is set such that a 0 dBm measurement input (or 2.87 dBm at the input of U4 on board 017) will produce a 1 volt signal at the output of amplifier U14. The U14 output is the detected signal path to preamp and display scaling board 015.

5.4.10.04 The limited ac output of detector/first limiter U11 (017 board) is presented to second limiter U12 (017 board). Limiter U12 has a very high gain for low signal levels. Thus, it strips all amplitude variations from the signal and produces a square-wave output which contains only frequency information. This is the FR + 100 kHz signal sent to the Generator Function for lock on and tracking when using TRACK mode.



SINGLE SIDEBAND
SUPPRESSED CARRIER MODULATOR

Fig. 5-9

Post Detection Measurement Processing

The detected signal path from U14 (017 board) provides parameter measurement information to various processing circuits on the preamp and display boards U15. On the 015 board, the detected signal is presented to two possible paths. One path leads to the level calibration amplifier U10 (015 board), and is used during impedance measurements. The other path leads to logarithmic amplifier U7 U8 Q6, and is used during level and return loss tests.

The impedance pathway through amplifier U10 is selected by a logic low IMP control signal which turns ON transmission gate U11B (015 board). The gain of the impedance calibration amplifier is set to remove any accumulated processing error so that impedance traces on the CRT screen will be correctly scaled.

The level return loss pathway through log amplifier U7 U8 Q6 is selected by a logic low IMP control signal which turns ON transmission gate U11C (015 board). The log converter changes the dc parameter measurement from a linear to a logarithmic function of the input voltage. The log converter has a 40 dB input range. It can accept inputs from 31.6 mVdc to 3.16 Vdc, representing -30 dB to +10 dB with respect to a 0 dBm control setting. (A 1 volt signal input to the log amplifier is considered to be 0 dB, and the 0 dBm control is normally set to provide this level.) The log converter will place the resulting display trace at the 0 dB line on the screen.

Refer to schematic diagram, Figure 8-11, for details of the log converter circuit. The log converter achieves its performance by using the inherent logarithmic relationship of the current property of transistor Q6A base-emitter junction. In the actual circuit a matched transistor Q6B U8B is used to subtract out the normal junction voltage (60 mV) and its 2.2 mV/°C temperature variation. The input signal impressed on R38 causes a current flowing current through R38 which must be balanced during U8 operation by collector of Q6A. A feedback voltage from U8's output is level-locked to U8B and applied to Q6A emitter-base junction. The feedback voltage becomes logarithmic in causing a feedback current to flow in the collector circuit of Q6A. The circuit actually compares the input current with a reference current and produces an output which is proportional to the log of the ratio between the two currents.

Amplifier U7 with transdiode Q6A and U8 with transdiode Q6B perform the comparison operation via the series-opposing connection of the transistors Q6A Q6B. A reference current of 100 μ A is set by zener reference diode VR1 and resistors R34 and R33. When the input voltage is 1.0 volt, the current through R38 will also be 100 μ A. This establishes the zero-output reference level. Resistor R34 and diode U8 provide closed loop stability. Divider R35 R36 R37 determines the output scale factor and provides temperature compensation.

5.4.11.06 The log converter output is a dc signal proportional to the level or negative return loss (in dB), being measured. Level return loss calibration amplifier U9 (015 board) has gain set to remove any accumulated processing errors, so that level and return loss traces on the CRT screen will be correctly calibrated.

5.4.11.07 Voltage follower U12 (015 board) receives its input from either the impedance or the level/return loss post-detection processing path. The voltage follower merely buffers the signal path. It imposes no gain or loss.

5.4.11.08 The measurement signal from voltage follower U12 is processed through scaling amplifier U13 (015 board). The gain of scaling amplifier U13 is controlled by the X1, X2, X5, X10 VERTICAL SCALE MULTIPLIER buttons. The gain changes determine the total amplitude which a displayed trace will have on the CRT screen. That is, the gain changes select the full-scale measurement range which will be visible on the CRT screen.

5.4.11.09 In addition, scaling amplifier U13 (015 board) imposes a dc offset on the measurement signal during both level and return loss tests. The dc offset raises the displayed measurement trace 3/4 of the way up the scale on the CRT screen. This causes a 0 dB reference level to appear correctly at the 0 dB line on the screen, instead of at the bottom line on the screen. No dc offset is imposed during impedance tests. Thus, the 0-ohms reference level does appear at the bottom line on the screen.

5.4.11.10 The output of amplifier U13 (015 board) has a full scale amplitude of 7 Vdc. This is the DATA-ANALOG signal presented to the Data Conversion, Storage and CRT Display Function and to the X-Y Recorder Drive Circuit.

5.4.12 X-Y Recorder Drive

5.4.12.01 The X-Y recorder drive circuit on the 015 board makes the DATA-ANALOG (measurement) and the FREQ-ANALOG (frequency) signals available at the Y and X RECORDER terminals on the front panel. Scaling amplifier U14 (015 board) reduces the 7 volt full scale DATA-ANALOG signal by 2.9 dB to create a 5 volt full scale signal. This makes both the measurement data and the frequency outputs equal, with full scale amplitude of 5 volts.

5.4.12.02 The transmission gates in U17 (015 board) are used to control transmission of the two signals to the X and Y binding posts. The signals are gated ON whenever either of the two traces memories is being updated, via either CONTINUOUS UPDATE or SINGLE UPDATE selection. Amplifiers U15A and U15B buffer the X and Y output signals. The buffer amplifiers can provide 5 Vdc full-scale output to a high impedance load, or 1 mAdc full scale output to a 100 ohm load.

5.4.13 Data Conversion, Storage, and CRT Display Function: Detailed Circuit Theory

5.4.13.01 The Data Conversion, Storage, and CRT Display Function comprises:

1. Tracking A/D converter board (0195-02-006);

2. Memory Circuit Board (0195-02-004);

3. Memory Timing Board (0195-02-005);

4. Control Logic Boards 1 and 2 (0195-02-011 & 0195-02-012);

5. Deflection Amplifier Board (0195-02-007).

See paragraph 8.3.07 for an overall description of the function's operations. Refer to the following paragraphs for detailed circuit theory.

5.4.14 A/D Conversion

5.4.14.01 The tracking A/D converters on board 006 sample and digitize the DATA ANALOG and FREQUENCY ANALOG signals into two 8-bit-parallel digital data streams. The digitized DATA ANALOG signal samples are stored in memory. The digitized FREQUENCY ANALOG signal samples specify the memory locations into which the digitized data samples are to be stored. A 50 kHz clock from memory timing board 005 synchronizes the conversion operations with memory writing (storage) and reading (display) operations. A negative $R/\overline{W}$ pulse instructs the memory timing board 005 to store the data in a memory whenever a frequency incremental change is detected.

5.4.14.02 The tracking A/D converter board 006 contains two nearly identical converters. One converter operates on the frequency signal voltage from the sweep generator. The other converter digitizes the measurement function signal voltage from the measurement function. The two converters operate essentially independently of each other except that when the frequency A/D converter increments (or decrements) it halts the data A/D converter for a very short period of time to stabilize it for entry into memory.

5.4.15 Frequency A/D Conversion

5.4.15.01 In sweep mode, the FREQUENCY ANALOG signal ramps from 0 to +5 volts in approximately 5 seconds (slow sweep). Amplifier U11 (006 board) scales and inverts this FREQUENCY ANALOG to ramp from 0 to -7 volts. Summing amplifier U12 (006 board) algebraically adds the FREQUENCY ANALOG signal and a quantized frequency feedback signal to obtain an error signal. The error signal at U12 output equals $2\frac{1}{2}$ times the difference between the magnitudes of the FREQUENCY ANALOG and quantized feedback signals. The FREQUENCY ANALOG signal is a continuous function while the quantized frequency signal changes in 27 millivolt increments (7 volts/256).

5.4.15.02 An incremental change in the quantized frequency signal represents a frequency change equal $1/256$ of a sweep range. The FREQUENCY ANALOG signal requires approximately 19.5 milliseconds (5 seconds/256) to sweep across one increment of frequency (slow sweep).

5.4.15.03 As long as the error signal is less than ± 50 volts, the outputs of window comparator U16/U17 (006 board) are both at logic 0. The comparator strobe (an inverted 50 kHz clock) samples the comparator outputs. So long as both are at logic 0, a steady logic 1 is applied to

the data COUNT flip-flop U6A via gates U2C/U2D. The 50 kHz clock sets flip-flop U6A. The COUNT flip-flop when set has two important effects:

1. It inhibits clock gate U3A thereby holding the up/down counter in its present state;
2. It releases COUNT flip-flop U6B from its set state to free the DATA A/D converter.

5.4.15.04 Therefore, the DATA A/D converter only operates when the FREQUENCY A/D converter has locked onto the FREQUENCY ANALOG signal. Note also that an error signal of ± 50 millivolts represents a 20 millivolt difference between the analog and the quantized signals. Recall that a quantized increment (or 1 bit) has a value of 27 millivolts. Therefore the difference between the analog signal and the quantized signal is less than one bit when the error signal is less than ± 50 millivolts.

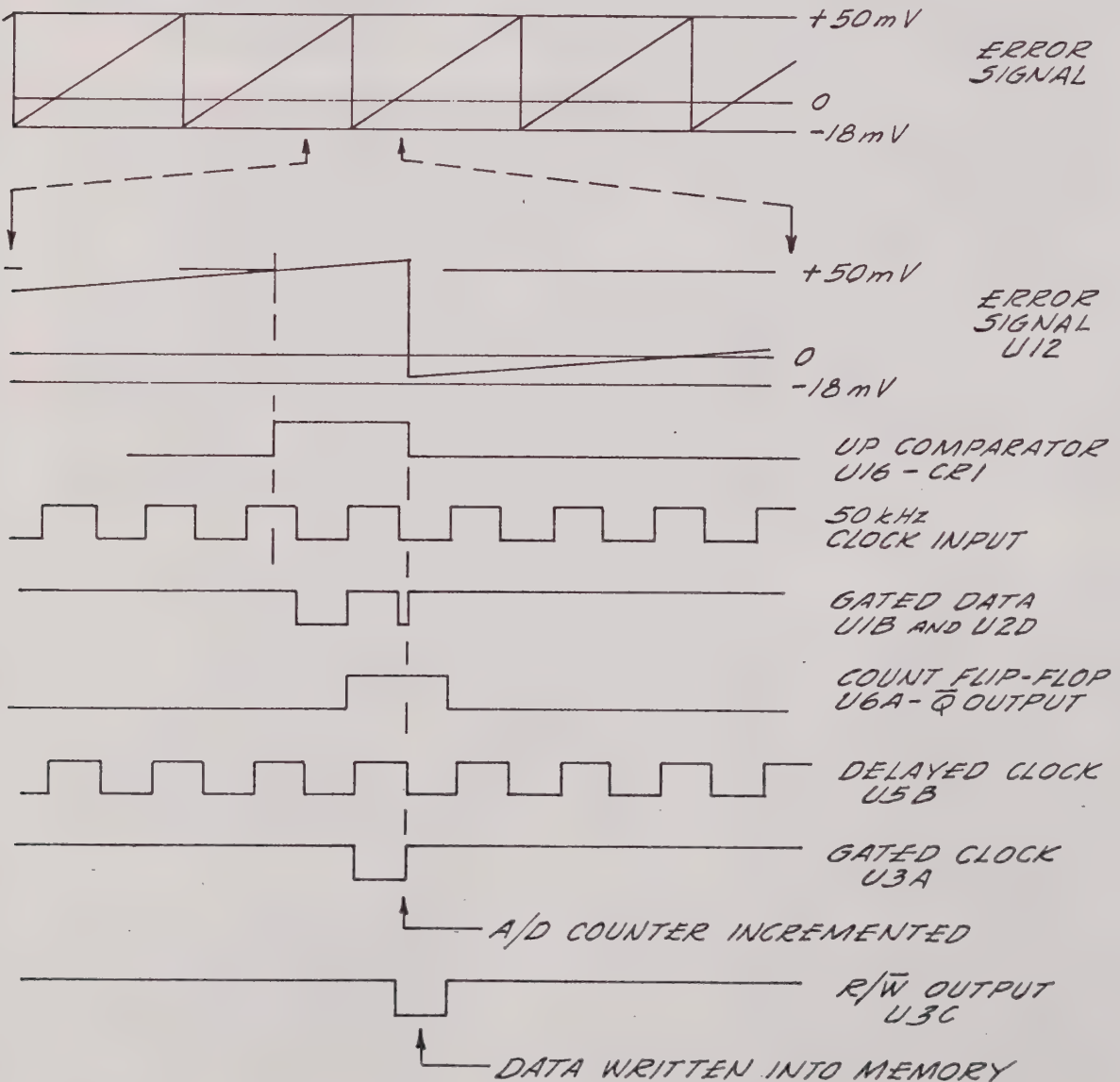
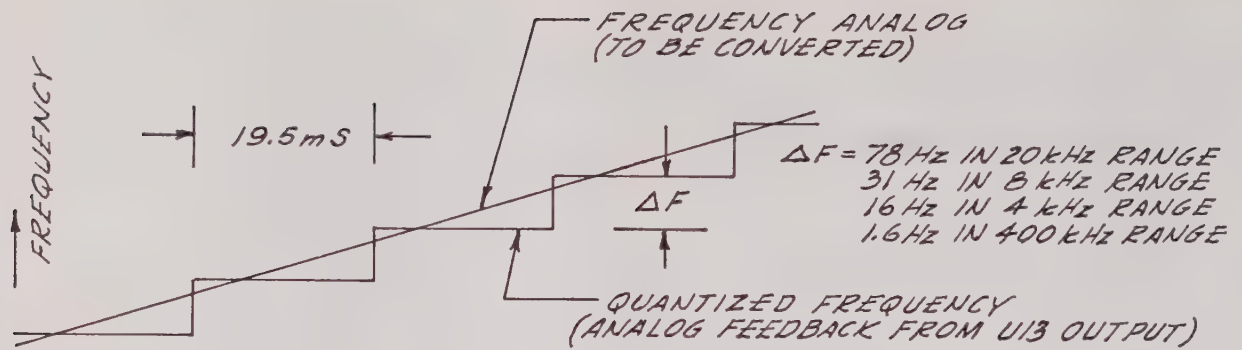
5.4.15.05 As long as the error signal remains smaller than ± 50 millivolts, flip-flop U6A (006 board) will remain set. Since the scaled FREQUENCY ANALOG requires approximately 19.5 milliseconds to change by 27 millivolts, the data A/D converter can take more than 900 samples in order to lock-on and track the DATA ANALOG signal, during the time that the frequency A/D output remains fixed.

5.4.15.06 When the error signal exceeds ± 50 millivolts it indicates that the scaled FREQUENCY ANALOG signal has changed by more than 20 millivolts (slightly less than one frequency increment). This change is sensed during the next strobe period and UP-DOWN flip-flop U2A/U2B (006 board) is either set or reset in accordance with the polarity of the error signal (set for a positive error, reset for a negative error). On the next positive edge of the clock signal, flip-flop U6A is reset thereby enabling clock gate U3A and setting flip-flop U6B.

5.4.15.07 Enabled clock gate U3A passes a 50 kHz clock pulse, which has been delayed slightly at U5B, to increment or decrement up/down counter U7/U8. The digital outputs of the up/down counter are converted to the quantized frequency analog feedback signal in a D/A converter comprising R-2R ladder R1 through R18 and amplifier U13, (006 board). The new quantized signal is now restored to within 20 millivolts of the FREQUENCY ANALOG signal, and COUNT flip-flop U6A will be reset by the next 50 kHz clock pulse. Thus, within one clock period, the frequency A/D converter will re-lock on the analog signal. See Figure 5-10 for pertinent waveforms.

5.4.15.08 During that one clock period, the DATA A/D up-down counter input is blocked so that its output remains fixed. The $R/\overline{W}$ line, normally at logic 1, goes to logic 0 during the second half of the clock period. This instructs the memory timing (005 board) to write the data, from the data A/D up-down counter, into the address indicated by the new output of the frequency A/D up-down counter.

5.4.15.09 The $R/\overline{W}$ pulse is inhibited upon receipt of any TRANSMIT RETRACE pulse from the generator whenever the generator is retracing in SWEEP mode (or when an external generator is retracing with T195 in TRACK mode). This prevents updating a memory when



FREQUENCY A/D CONVERSION WAVEFORMS

Fig. 5-10

the frequency A/D converter cannot accurately track the analog signal.

5.4.16 Data A/D Conversion

5.4.16.01 The data A/D converter operates essentially in the same manner as the frequency A/D converter. Recall that the frequency A/D converter allows the data converter to operate only when the frequency A/D converter has locked on the FREQUENCY ANALOG signal.

5.4.16.02 Like the up/down counter of the frequency A/D converter, up/down counter (U9/U10) will be clocked each time its analog input (DATA ANALOG) signals to the A/D converter changes by a 27 millivolt increment (equivalent to 1 data bit). In this case, an incremental change represents either a 0.016 dB (X1 scale) or a 3.9 ohm (X1 scale) change in input value. The data A/D converter can track a DATA ANALOG signal that changes at a rate of up to 1.36 mV/sec.

5.4.17 Small Signal Lockout In Track Mode

5.4.17.01 Comparator U20 monitors the DATA ANALOG signal and, with the T195 in TRACK mode, applies a RESET signal via gate U5D whenever the DATA ANALOG signal falls more than 190 millivolts negative. The RESET signal clears the data up/down counter to zero. It also sets flip-flop U6A to halt the frequency A/D converter. This prevents the frequency A/D converter from following the generator frequency when there is no valid input frequency data from the generator to track.

5.4.18 Data Conversion Band Limits

5.4.18.01 Each A/D converter is prevented from operating if its analog input signal exceeds the normal operating range (0 to -7 volts for DATA-ANALOG, 0 to +5 volts for FREQ ANALOG). As the analog signal changes from a low to a high absolute value, the up/down counter receives an instruction to count up (UP/DOWN = 1). Similarly, the up/down counter receives an instruction to count down (UP/DOWN = 0) when the analog signal moves from a high to a low absolute value. Upon reaching a count of 0 (when counting down) or 255 (when counting up) the $\overline{CO}$ counter output, through U2D or U4D, blocks any further count until the UP/DOWN command changes. This prevents the counter from attempting to over-range beyond the eight bits provided and supplying a low digital value when the analog signal is at a high absolute value or vice versa.

5.4.19 Memory Storage and Display

5.4.19.01 Memory operations are controlled by memory timing board 005. All timing signals are derived from a 4 MHz crystal controlled oscillator. Decade counter U1 (005 board) and four-bit binary counter U2A divide the 4 MHz signal into 400 kHz, 200 kHz, 100 kHz, 50 kHz, and 25 kHz clocks.

5.4.19.02 The 50 kHz clock allocates read/write time slots for addressing a memory prior to write (storage) and (display) operations. New addresses are switched at the transitions of the 50 kHz clock and are given 5 microseconds to stabilize before strobing data in or out of a memory.

5.4.19.03 Time/base counter (stages 2 through 9 of U3 on the 005 board) steps through 256 increments at a 25 kHz rate. (The first stage of U3 divides the 50 kHz clock.) Clock interlock U5A/U5B and four-stage counter U2B force the time base counter to dwell at zero for 8 counts of the 25 kHz rate. An inverted output of clock interlock gate U5B (005 board) serves as the CRT blanking control signal. One stage beyond, the time base counter (stage 10 of U3) produces a square wave called 50 Hz (actually 25 kHz/2(256 + 8), or about 47.3 Hz), with a 21.12 millisecond period. This signal is used to alternate display traces.

5.4.19.04 The eight-bit binary output of the time base counter represents the read address. Each read address word remains on for 40 microseconds (two 50 kHz clock periods).

5.4.19.05 D/A converter U4 (005 board) changes the cycling address words into a ramp for use as the CRT horizontal sweep signal. The 320 usec dwell time allows sufficient retrace time for the CRT circuits.

5.4.19.06 The eight-bit read address, from the time-base counter, and the eight-bit write address, from the frequency A/D up-down counter, are both connected to inputs of the address selector, U12 and U14. Normally, when the $R/\overline{W}$ line is at logic 1, the read address appears at the selector output. When the $R/\overline{W}$ line goes low as the frequency A/D up-down counter increments (or decrements), the write address appears at the selector output.

5.4.19.07 Both read and write addresses are also connected to 8-bit comparator U13 and U15. The comparator uses the same integrated circuit device type as the address selector, but with different control connections so that it operates as an 8-bit exclusive-NOR circuit. When the two addresses coincide, if enabled by the FREQ MARK pushbutton, a burst of 200 kHz square wave is gated in U9B and added to the CRT vertical deflection signal (007 board).

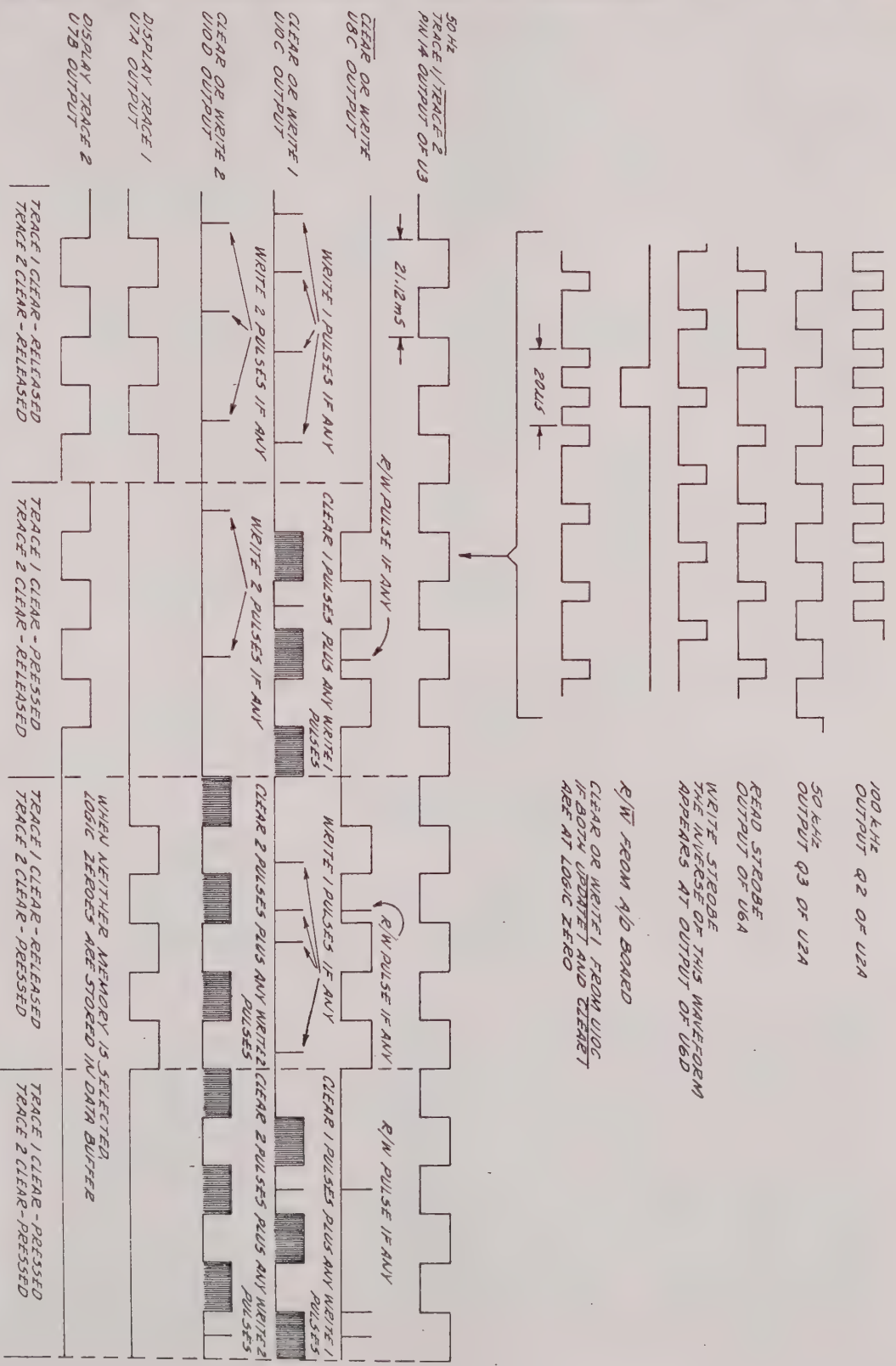
5.4.19.08 Several other timed control signals are generated in the 005 board as follows:

The DISPLAY TRACE 1 and DISPLAY TRACE 2 signals are generated in U7A and U7B. These are opposite phases of the 50 Hz signal from the time base counter, except that both are held low in the presence of a $\overline{CLEAR}$ signal.

A READ STROBE is generated in inverted form in U6B, and inverted in U6A. The read strobe is a 5 microsecond pulse occurring every 20 us (50 kHz clock rate), and timed so that it cannot coincide with a logic zero on the $R/\overline{W}$ line.

A WRITE STROBE, existing only in inverted form, is generated in U6D. It is equivalent to the read strobe but phase shifted 90°. The write strobe coincides with the second half of any $R/\overline{W}$ zero.

A $\overline{CLEAR OR WRITE 1}$ signal is generated in U7C, U9A and U10B and C. This line carries a 5 us write pulse whenever update 1 (from control logic), a $R/\overline{W}$ zero, and the write strobe all coincide. It also carries a train of 5 us clear pulses, coincident with the read strobe, when a clear 1 (from control logic) is present.



MEMORY CONTROL SIGNALS

Fig. 5-11

A corresponding CLEAR OR WRITE 2 signal is generated in U7D, U9C, and U10 A and D.

A CLEAR or WRITE signal generated in U8 B and C is a logic one whenever both clear 1 and clear 2 lines (from control logic) are at logic 1, or when a write pulse (R/W at logic 0) occurs during clear. Because of 50 Hz gating of the clear signals in the control logic (012 board) the clear functions for each trace in these last three signals occur only during that phase of the 50 Hz signal when the corresponding output select line would be high if it were not held low by the clear. The timing relationships are shown in Figure 5-11.

5.4.20 Memory Selection in Sweep Mode

5.4.20.01 In SWEEP tuning mode, provision is made for automatically updating the two traces, each with its own input data, on alternate generator sweeps. Memory control logic boards 011 and 012 determine which memory is updated and which input (LINE 1, LINE 2 or STD) is selected in response to operator control settings. Flip-flops U5B and U7A on the memory control board specify the updating of memories 1 and 2 respectively. When trace 1 CONTINUOUS UPDATE or TRACE 2 CONTINUOUS UPDATE pushbutton is engaged (closed), a logic one is transmitted through two series gates (U1A/U2B or U1B/U2A) to the D-input of the corresponding update flip-flop (U5B or U7A). All flip-flops (in sweep mode) are clocked by the TRANSMIT RETRACE pulse from the sweep generator function.

5.4.20.02 With a logic one present at the D-input of an update flip-flop, that flip-flop becomes "set" on the next TRANSMIT RETRACE pulse and will remain "set" until the first transmit retrace pulse after removal of the logic 1 input. This makes memory updating start at the beginning of a frequency sweep and end with the end of a sweep.

5.4.20.03 Time share flip-flop U6A causes memory updating and input selection to alternate between frequency sweeps when both memories are directed to update from separate inputs. Under this condition, logic ones are presented to the J- and K-inputs of time share flip-flop and its state switches with each TRANSMIT RETRACE pulse. The Q and $\bar{Q}$ outputs of time share flip-flop cause the logic 1 to alternate between the D-inputs of the update flip-flops.

5.4.20.04 In the case where both memories are to be updated from the same input signal it is not necessary to time share the analog processing circuits. The ASSIGN INPUT pushbutton switches form a hard-wired exclusive-OR combination circuit to block the output of time share flip-flop. Although the time share flip-flop still alternates its output states, it has no effect on update flip-flops U5B and U7A. Both memories are updated on one generator sweep.

5.4.20.05 Holding flip-flops U5A and U6B store the SINGLE UPDATE pushbutton commands. Each SINGLE UPDATE command force-sets its holding flip-flop when pressed momentarily. The holding flip-flop output is OR-gated with the path from the CONTINUOUS UPDATE latching pushbutton and the resulting logic 1 is presented to the D-input of the related update flip-flop.

The next TRANSMIT RETRACE pulse sets that update flip-flop. The TRANSMIT RETRACE pulse that sets the update flip-flops also resets the holding flip-flop. The next TRANSMIT RETRACE pulse resets the associated update flip-flop to complete a single update cycle.

5.4.20.06 Input select flip-flop U7B operates input selector relay K1 on input/output board 014. Gates U3A/U3B/U3D monitor the input assignments and place the input select flip-flop in the set state to select input A, and in the reset state to select input B.

5.4.21 Memory Selection In Track and Manual Modes

5.4.21.01 In track or manual mode, the choice of which trace is to be updated is entirely manual, with no automatic alternation. If TRACE 1 CONTINUOUS UPDATE is engaged, then a logic "1" appears at the D-input of update 1 flip-flop U5B and memory one will be updated. The input assignment will be routed through gate U3B to the input select flip-flop U7B.

5.4.21.02 To update memory two, it is necessary to release TRACE 1 CONTINUOUS UPDATE and to engage TRACE 2 CONTINUOUS UPDATE (or SINGLE UPDATE). Under these conditions update flip-flop U7A will be set and time share flip-flop U6A will be reset. Input assignment passes through gate U3A to reach the input select flip-flop.

5.4.21.03 In Track and Manual modes, the 50 Hz signal from the time base counter (005 board) is used to clock the flip-flops. Only the first clock pulse after a change in pushbutton switch position has any effect.

5.4.22 Memory Clearing

5.4.22.01 A memory is cleared by placing logic zeroes at its inputs and applying write pulses as the memory locations are incremented through the full range (0 to 255). In the normal read cycle, the read addresses cycle through the memory locations continuously. So, to clear memory, the data gate (U1/U2 on 004 board) is switched by low CLEAR OR WRITE pulses while write pulses (high CLEAR OR WRITE 1 or CLEAR OR WRITE 2 pulses) are continuously applied in the usual "read" time.

5.4.22.02 Writing zeroes during the "read" times, leaves the normal "write" time periods available for writing data into either memory as necessary. This is essential since the data lines are shared by both memories, thus data gate U1/U2 (004 board) may be switched momentarily to write as required, then reswitched to apply logic zeroes without interrupting the clearing sequence.

5.4.22.03 To prevent spurious readout of a memory that is being both written and read in the same time slot during clearing, the memory selector (U3/U4 on 004 board) is switched to apply logic zeroes into the data buffer (U5/U6 on 004 board) when both output select lines are at logic zero during the read periods for the memory being cleared. Thus, the vertical D/A converter (U23 on 004 board) sees all memory data words as zeroes while the memory is being cleared.

5.4.23 CRT Display Drive

5.4.23.01 Deflection amplifier board 007 amplifies both horizontal and vertical signals and applies them to the cathode ray tube. Horizontal deflection amplifier Q13-Q16 (007 board) sums the HORIZ and HORIZ POS. signals. HORIZ is the horizontal sweep signal (time base counter output converted to analog) and HORIZ POS centers the trace horizontally.

5.4.23.02 Vertical deflection amplifier Q5-Q8 (007 board) sums five signals:

1. VERTICAL, from the vertical D/A converter, or AVERAGE, from the average-over-band circuit;
2. MARKER, a burst of 200 kHz square wave;
3. TRACE 1 POSITION; and
4. TRACE 2 POSITION. These are dc offset signals produced at the position panel controls. Each is switched to zero in the logic control circuits when the other trace is being displayed;
5. VERTICAL REFERENCE, from adjust pot R11.

The VERTICAL or AVERAGE signals are proportional to measurement data. The MARKER signal indicates the sweep oscillator frequency. the VERT REF signal positions the zero reference (with VERTICAL signal set at 0 dBm).

5.4.23.03 Normally, both traces have the same reference position. However, the two traces may be separated when one or both V-POS/REF toggle switches are in the up, or non-ref position. The 50 Hz signal alternately gates the TRACE 1 POSITION (on logic 1 half-cycle) and TRACE 2 POSITION (on logic 0 half-cycle) voltage as selected by the related V-POS control to the vertical deflection amplifier.

5.4.23.04 The AVERAGE OVER BAND function permits a portion of the trace 2 display, between two selected frequencies, to be shown as a horizontal line representing the average data level over the selected band. The band limits are selected as dc analog levels in the LO FREQ and HI FREQ BAND LIMITS panel controls. These levels are compared with the horizontal deflection signal in threshold comparators U3 and U4 (007 board).

5.4.23.05 When the comparators indicate that horizontal position is within the band and the 50 Hz signal indicates that trace 2 is being displayed, logic gate U1C turns ON analog transmission gate U2B, connecting the vertical signal to the averaging circuit. Capacitor C5 charges to a voltage which is the average value of the vertical position signal during the time U2B is ON. When U2B is OFF there is no charge or discharge path for C5 so the voltage remains constant. U5 is a unity-gain buffer to prevent C5 discharge through load circuits.

5.4.23.06 Also when horizontal position is within the selected band and trace 2 is being displayed, if the averaging circuit is enabled by the AVERAGE OVER BAND pushbutton switch, logic gates U1A and U1B turn transmission gate U2C ON and gate U2A OFF. This dis-

connects the normal vertical signal from the vertical deflection amplifier input and connects the average signal in its place.

5.4.23.07 During impedance measurements, where the display is a linear ohms scale, the simple capacitor averaging circuit produces the desired average ohms output. However, the average-over-band is more often used with return loss measurement. (It could also be used with level measurement.) Here the display is on a linear dB scale. The proper average reading should not be the linear dB average, but the power average expressed in dB. Let y be the display level, expressed in dB above the bottom line on the display. The simple averaging circuit would give us

$$\bar{y} = \frac{1}{f_2 - f_1} \int_{f_1}^{f_2} y \, df,$$

but the desired power average is

$$(\text{pwr AV})_{\text{dB}} = 10 \log_{10} \left[\frac{1}{f_2 - f_1} \int_{f_1}^{f_2} \frac{y}{10} df \right]$$

If y is constant over the band, the two expressions are equivalent, but the more y varies over the band the more dissimilar they become. In the T195, a compromise is provided. When average-over-band is used during return loss or level measurement, gate U2D is turned ON. Capacitor C5 is now charged through a non-linear circuit, to a voltage which is a compromise between the average and the peak value of the vertical signal in the selected band. The characteristics of the non-linear circuit are switched (015 board) in accordance with the VERTICAL SCALE MULTIPLIER selection to provide optimum compromise. This compromise "quasi power average" is analogous to the "quasi rms detector" commonly used in noise measurement.

5.4.23.08 The CRT BLANKING signal from the memory timing circuits (005 board) is a logic-zero pulse on a line which is normally at logic one, occurring when the display horizontal sweep retraces. This negative pulse is amplified in Q17 and Q18 and applied to the intensity control grid of the CRT to blank the screen during retrace.

5.4.24 Generator Function: Detailed Circuit Theory

5.4.24.01 The generator function comprises:

1. Oscillator Board (0195-02-074);
2. Part of Measurement Circuit Board (0195-02-017).

Refer to paragraph 5.3.08 for an overall description of the function. Refer to the following paragraphs for detailed circuit theory.

5.4.25 Frequency Generation

5.4.25.01 Refer to Figure 5-6 (sheet 1) and schematic diagram Figure 8-17 for aid in understanding the following descriptions. The generator uses a heterodyne method to produce the FS signal frequency. This technique produces an FS signal having a high degree of spectral purity over the 0 to 20 kHz frequency range.

5.4.25.02 The FREQUENCY ANALOG COMMAND is a dc voltage, generated in different ways depending on the TUNING mode selected, which controls the generator frequency. The FREQUENCY ANALOG COMMAND is also the signal from which memory addresses are derived in the Data Conversion, Storage and CRT Display Function.

5.4.25.03 The FREQUENCY ANALOG COMMAND voltage ranges from zero at zero send frequency to +5 volts at maximum frequency for the range selected. It is attenuated in the FREQ RANGE CONTROL to provide a signal which is proportional to the actual frequency required, rather than to the required proportion of full scale. It is then summed with a negative frequency analog feedback signal. The resulting error signal, at amplifier U17 output, is the voltage control input to VCO (voltage-controlled-oscillator) U16 (074 board).

5.4.25.04 The 1.0 to 1.2 MHz output of the VCO is divided by 10 in decade counter U15. The divided signal is presented as 180 degree out of phase square waves to bilateral transmission gates U6A and U6B via drivers U14C and U14D. The transmission gates serve as the heterodyning elements, operating as a suppressed carrier modulator.

5.4.25.05 The reference signal is obtained as a 100 kHz square wave from the frequency counting function. This square wave is filtered by three-pole low-pass active filter U2 (074 board). The 100 kHz signal is then filtered again by biquad filter circuit U3/U4/U5 (074 board).

5.4.25.06 The combined filtering of the 100 kHz square wave extracts a pure sine wave fundamental which is presented as two 180° out of phase reference frequency signals to the transmission gate inputs.

5.4.25.07 The switching action of the VCO frequency signals on the reference signals produces two outputs which are summed at amplifier U7 (074 board). The resulting output of U7 contains the sum and difference frequencies. Six-pole low-pass filter U8/U9/U10 passes the difference frequencies below its 25 kHz cutoff. Sum frequencies are attenuated by 90 dB or more. The second and third harmonic content of the output signal is -65 dB or lower.

5.4.25.08 The level of the sweep oscillator signal is, at this point, ≈ 0.75 V rms (-0 dBm into 600 ohms). The signal passes on to the send attenuation circuit for leveling. (Refer to paragraph 5.4.06).

5.4.26 Frequency-To-Voltage Converter

5.4.26.01 The frequency-to-voltage (f/v) converter is used as the feedback element in the servo loop which controls the generator frequency. Two outputs of the decade counter U15 are combined in U14A to provide a signal at one-fifth VCO frequency, or 200 kHz to 240 kHz. This signal is used to trigger monostable multivibrator U12. The timing circuits of U12 are set for an output pulse duration of 2.5 μ s. Thus for an input frequency of 200 kHz, the output waveform will be balanced, 2.5 μ s ON out of a 5 μ s period. The average levels at Q and $\bar{Q}$ outputs will be equal. At 240 kHz input, U12 is ON for 2.5 μ s out of a

4.167 μ s period, or 60% of the period. The average level at the Q output will be 60/40 or one-and-one-half times that at the $\bar{Q}$ output.

5.4.26.02 The average levels at the Q and $\bar{Q}$ outputs of U12 are subtracted at the input of amplifier U11. The output of U11 is zero when U12 trigger frequency is 200 kHz, or when FS is zero. U11 gain is scaled to provide a dc analog of FS with a scale factor of -250 V/Hz (microvolts per hertz), or a range of zero to -5V for FS from zero to 20 kHz. This is the FREQUENCY ANALOG FEEDBACK signal.

5.4.26.03 Since U12 is a TTL device while the rest of the generator function is made up of C-MOS and linear devices, the circuits including transistors Q1 through Q5 are used to provide the necessary level shifting and interfacing.

5.4.27 2600 Hz Skip

5.4.27.01 The 2600 Hz skip circuit, when activated, prevents the sweep generator from producing any output signal between 2450 Hz and 2750 Hz. Summing amplifier U23 (074 board) and window comparator U24A/U24B comprise the 2600 Hz skip circuit.

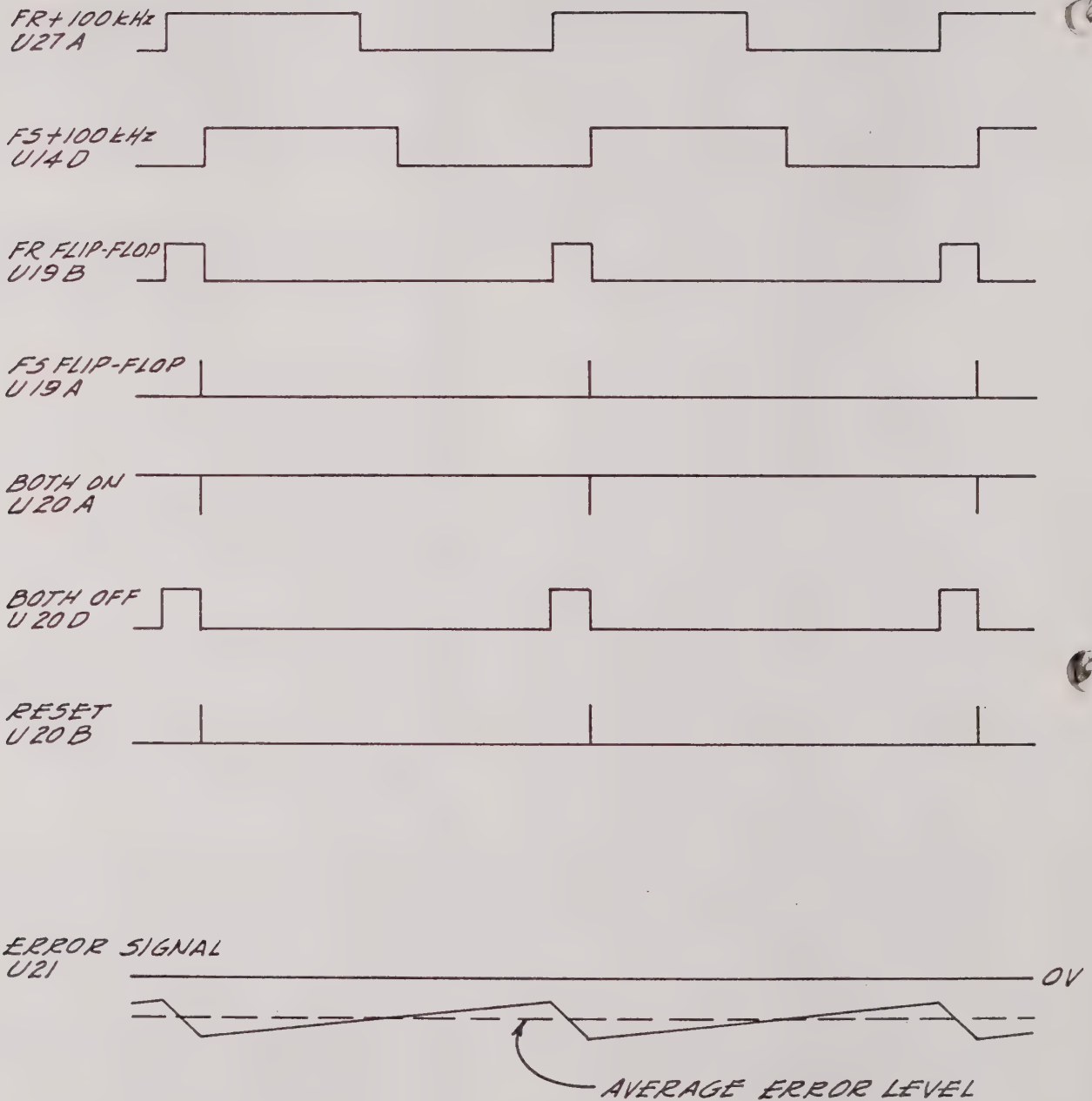
5.4.27.02 The summing amplifier algebraically adds the negative frequency analog feedback voltage and a positive reference voltage of approximately 650 millivolts (representing 2600 Hz). The difference, amplified by a factor of 2.5, indicates both the sense and magnitude of deviation from 2600 Hz. The window comparator, with its limits nominally set at ± 98.75 millivolts (± 150 Hz), produces a logic zero output whenever the frequency analog feedback signal indicates a frequency between 2450 and 2750 Hz. The logic zero inhibits gate U1A from passing the 100 kHz carrier signal to the modulator. In the absence of the carrier signal, no output frequency is generated although the VCO still sweeps normally.

5.4.27.03 When the frequency analog signal exceeds the window limits, the comparator produces a logic one to permit normal frequency output. A released 2600 SKIP pushbutton forces a logic one on the output of the 2600 Hz skip circuit.

5.4.28 Frequency Analog Command Generation

5.4.28.01 In MANUAL TUNING mode, the frequency analog command is obtained directly from the ten-turn precision MANUAL TUNING control potentiometer located on the front panel.

5.4.28.02 In SWEEP TUNING mode, the frequency analog command is a linear ramp voltage, derived by charging capacitor C35 through constant current generator Q7. When the ramp reaches its upper limit, as set by R98, the output of comparator U26, gated through U27D, triggers monostable multivibrator U28A, whose output is a 30 ms pulse. (U28B is present but not used). This turns ON transistor Q8 which provides a rapid discharge path for C35, causing the frequency analog command to return to zero. U28A output, after shaping and buffering in schmidt-trigger circuit U1C and U1D, is the TRANSMIT RETRACE signal, used to set the R/W line high, disabling



PHASE ERROR DETECTION WAVEFORMS
INPUT PHASE LEADING

Fig. 5-12

FR+100kHz
U27A

F5+100kHz
U14D

FR FLIP-FLOP
U19B

F5 FLIP-FLOP
U19A

BOTH ON
U20A

BOTH OFF
U20D

RESET
U20B

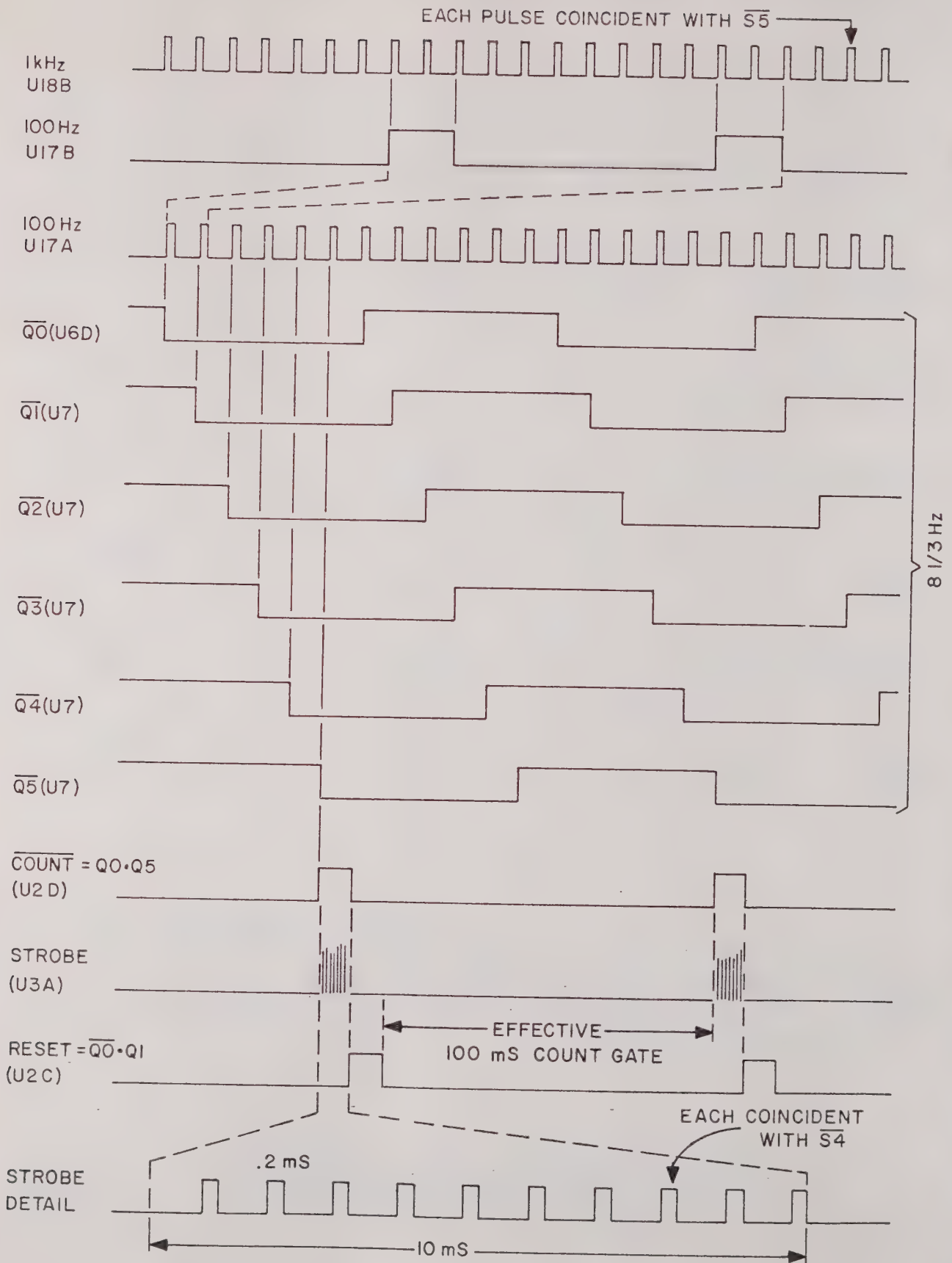
ERROR
SIGNAL
U21

AVERAGE ERROR LEVEL

0V

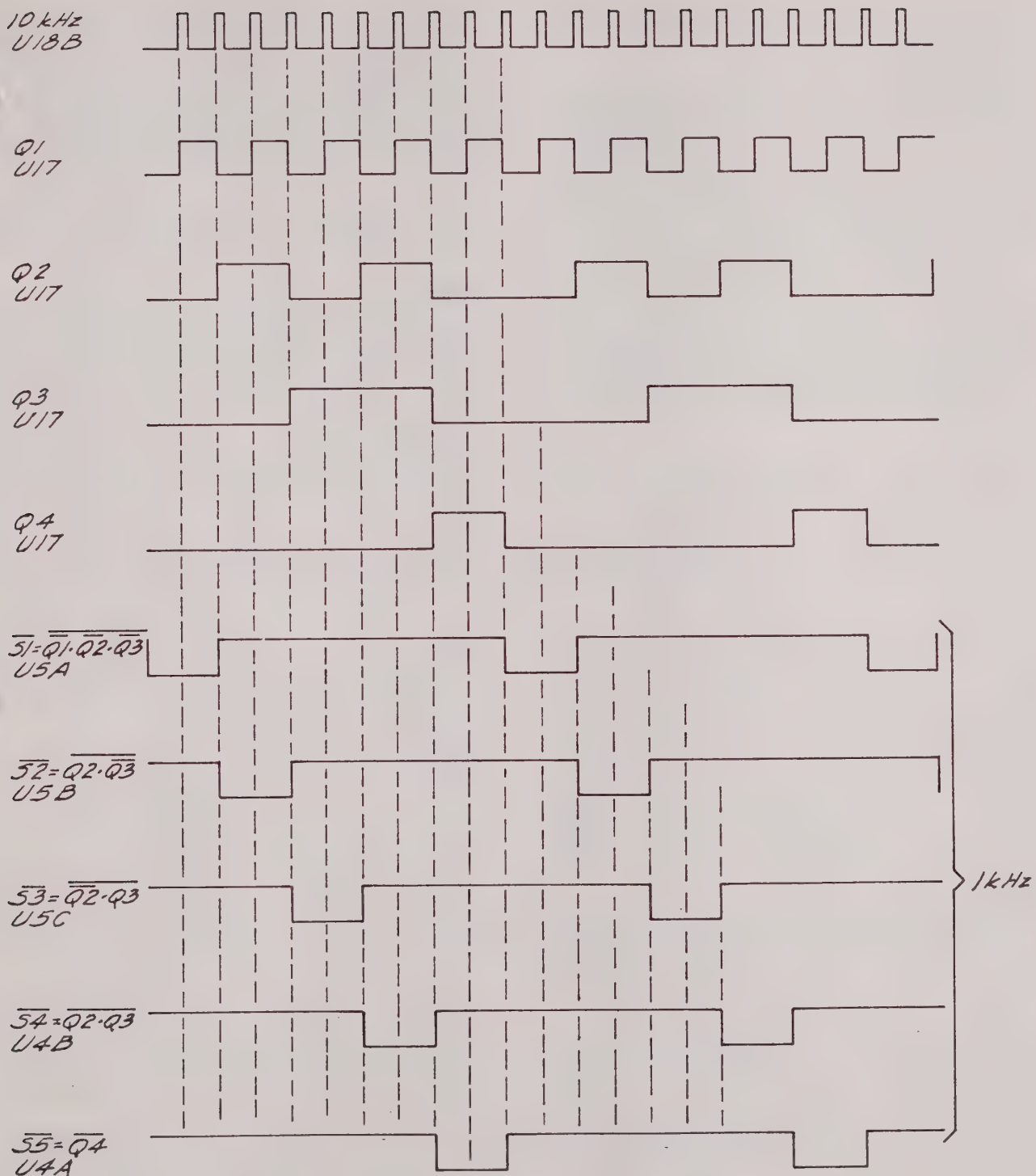
PHASE ERROR DETECTION WAVEFORMS
INPUT PHASE LAGGING

Fig. 5-13



COUNTING CONTROL SIGNALS

Fig. 5-14



MULTIPLEXING CONTROL SIGNALS

Fig. 5-15

the WRITE function, in the data conversion circuits, and to trigger automatic memory update alternation in the update control logic.

5.4.28.03 In TRACK TUNING mode, the VCO output after division by ten ($FS + 100$ kHz) is phase/frequency compared with the up-converted input signal frequency ($FR + 100$ kHz). Any comparison error is integrated to provide the frequency analog command. A comparison error produces a change at the integrator output. If there is no error, the frequency analog command will remain constant, at any voltage in its range, so long as $FS + 100$ kHz and $FR + 100$ kHz remain in precise phase agreement.

5.4.28.04 The output of the phase/frequency comparator indicates both sense (leading or lagging) and the magnitude of phase error. If there is an actual frequency difference (lock not acquired), the error magnitude will vary periodically at the difference frequency, but will always be in the right sense to bring the control loop toward lock.

5.4.28.05 The phase/frequency comparator consists of D-type flip-flops U19A/U19B (074 board) and reset generator U20 (comprised of S-R flip-flop U20B/U20C and gates U20A/U20D). A logic "0" TRACK signal (not in TRACK mode) inhibits the detector. Therefore, the detector operates only during TRACK mode.

5.4.28.06 In TRACK mode the two frequencies clock the flip-flops. As soon as both flip-flops have been set, the reset generator resets them again. In normal closed loop operation, with both incoming signals in phase coincidence, both flip-flops are set simultaneously and reset generator U20 instantly resets both. This results in very narrow "spikes" at the outputs of the flip-flops. These spikes, when averaged, result in identical (near zero) dc levels and no error signal is produced by difference amplifier U21 and integrator U22 output does not change. Integrator U22 has dead-zone diodes (CR2/CR3) to prevent small error voltages from producing an output change.

5.4.28.07 When the phase of the incoming $FR + 100$ kHz leads, as when its frequency is increasing, flip-flop U19B sets before U19A and its output pulses are wider, while narrow spikes remain on the output of flip-flop U19A. The wider pulses constitute a higher dc level than the spikes, so that the average level at the output of differential error amplifier U21 goes negative. The differential amplifier circuit includes some smoothing capacitance, but for wide pulses (large phase differences) leaves a substantial amount of ripple along with the average error level at its output. This negative level is integrated in U22 to produce an increase in the frequency analog command, causing the VCO frequency to increase and catch up, re-balancing the phase/frequency detector. Figure 5-12 shows the waveforms when the incoming signal phase is leading (frequency increasing). Figure 5-13 shows corresponding waveforms when the incoming signal phase is lagging.

5.4.28.08 If the incoming signal frequency is decreasing rapidly, as during the retrace of an external sweep-frequency generator, there will be a large positive error voltage at the output of U21. This is gated through U1B

and triggers monostable multivibrator U28A. Triggering occurs once on the rise of the error voltage and, depending on the circumstances, re-triggering may be caused by the error voltage ripple. U28A output remains high for milliseconds after the last re-trigger, producing TRANSMIT RETRACE PULSE. As in the SWEEP mode, the TRANSMIT RETRACE signal prevents data from being written into memory during the retrace.

5.4.29 Digital Frequency Display Function: Detailed Circuit Theory

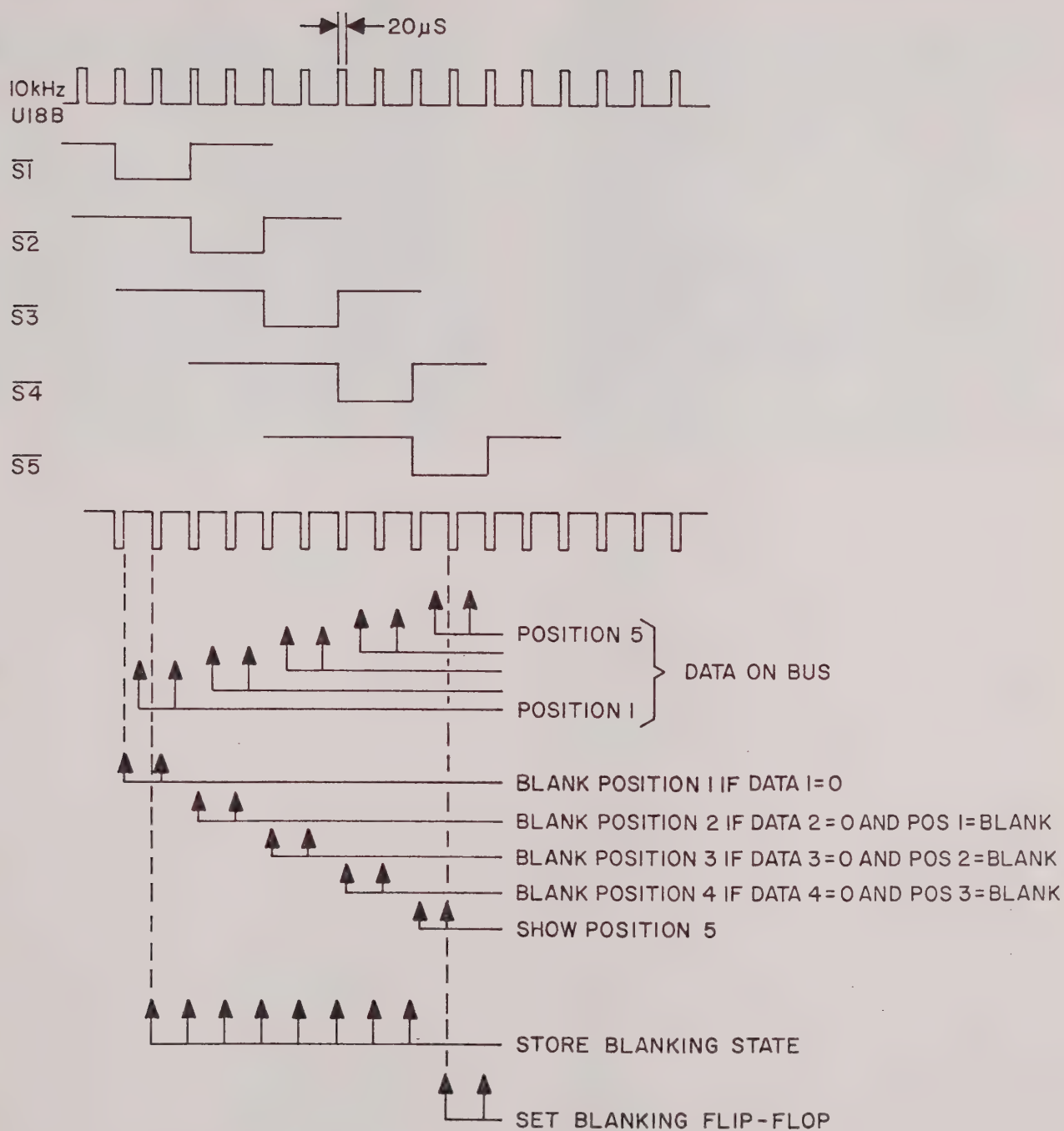
5.4.29.01 The Frequency Display Function comprises frequency counter and display board (0195-02-016). See paragraph 5.3.09 for an overall description of the function. Refer to the following paragraphs for detailed circuit theory. Use Figure 5-6 and schematic Figure 8-13 as reference aids to understanding the following descriptions.

5.4.29.02 Frequency measurement and display is accomplished by counting the $10 FS + 1$ MHz signal from the generator over a 0.1 second interval, and displaying the last five digits of the resulting count. Counting 10 times the send frequency for one-tenth of a second produces the same number as counting the send frequency for one second, but with a fast update which gives the appearance of continuously following a changing frequency. Since the frequency being counted is always in the 1.0 MHz to 1.2 MHz range, the most significant digit of the number counted is always a one. Omitting this digit from the display has the effect of subtracting 1 MHz from the input. The remaining five digits represent the frequency FS hertz, from less than 20 Hz to 20 kHz.

5.4.29.03 The $10 FS + 1$ MHz signal is counted in a chain of five BCD (binary-coded-decimal) ripple counters, U15A, U15B, U16A, U16B and U18A. At the end of the 0.1 second counting interval, the input is blocked to stop the count, and the content of the counter is transferred to a set of five 4-bit binary storage devices, U10 through U14, where it is available for display throughout the next counting interval. The counter is then re-set to zero, and a new count interval begins. The total time required for count interval plus control functions is 0.12 seconds, so that the count is up-dated 8.3 times a second.

5.4.29.04 The frequency count is displayed in a five-digit L.E.D. numerical display. The digits are multiplexed, that is, displayed one-at-a-time in sequence. Each digit is ON for 160 microseconds out of a total one millisecond scan period. The 1000 Hz scan rate gives the appearance of a continuous display.

5.4.29.05 The count storage devices, U10 through U14, have "three state" outputs. This permits their output connections to be hard-wired together in a common 4-bit bus. The common bus contains data from only one of the five storage devices at a time, in response to the multiplex control signals. The common bus, carrying a single BCD digit, goes to BCD to seven-segment decoder U8 and thence to seven-line LED driver U9 (a multiple common-emitter transistor array). The outputs of U9 are connected through current limiting resistors, to cathodes of the LED line segments. The cathodes of corresponding segments in all five digits are bussed together.



LEADING ZERO SUPPRESSION TIMING

Fig. 5-16

cathode ray tube. A potentiometer forms two arms of the bridge to allow adjusting the trace rotation as necessary.)

5.4.30.03 Regulators U1 and U4 (018 board) are three-terminal positive voltage regulators which change the 24 Vdc raw input into two +18 Vdc regulated outputs. The output of regulator U1 goes to square wave inverter U2/T2/Q1/Q2/T3. The output of regulator U4 goes to the positive input of dual voltage tracking regulator U3/Q3/Q4.

5.4.30.04 The inverter consists of timer U2 (086 board) which generates a 20 to 25 kHz square wave. This square wave passes through transformer T2 to switch transistors Q1 and Q2 on and off alternately. The collectors of the transistor have a square wave approximately 36 volts peak-to-peak. This square wave is applied to multi-secondary transformer T3. The square wave is also rectified into -18 Vdc by push-pull rectifier CR4/CR5. The -18 Vdc goes to the negative input of the dual 14 volt tracking regulator.

5.4.30.05 Transformer T3 has four secondaries. Secondary 1 has a 3:1 ratio and steps the voltage down to 12 volts peak. The 12 Vac is rectified to 6 Vdc by bridge rectifier

CR6/CR7/CR22/CR23. This 6 Vdc rides "piggy-back" on the output of a voltage multiplier for use as the CRT filament voltage.

5.4.30.06 Push-pull rectifier CR12/CR13 (018 board) changes the 12 Vac from secondary 4 to a 5 Vdc output. Bridge rectifier CR8-CR11 changes the 160 Vac from secondary 2 (9:40 turns ratio) to ± 75 Vdc.

5.4.30.07 Secondary 3 supplies 225 Vac to voltage octupler CR14-CR21 (018 board) which applies -2100 Vdc to a voltage divider chain. The voltage divider provides the necessary CRT voltages.

5.4.30.08 As previously mentioned, the ± 18 Vdc went to dual 14 volt tracking regulator U3 (018 board). The regulator, an integrated circuit, is designed to normally supply ± 15 Vdc outputs. However, resistors R10 and R11 change the negative output voltage to -14 Vdc while resistors R8 and R9 ensure that the positive voltage tracks the negative voltage symmetrically at +14 Vdc. Transistors Q3 and Q4 increase the current carrying capability of the regulator.

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6.2 MAINTENANCE - TROUBLE LOCATING

6.2.1 General

6.1.01 All Wilcom Products Inc. test equipment is warranted against defects in materials and workmanship for a period of one year from the date of delivery. Complete details of the warranty can be found on the title page of this manual.

6.1.02 Field repair of this test set is NOT recommended unless the repair will be made in a well equipped repair center. The technicians performing the repair should be familiar with digital circuitry, logic functions and state of the art semiconductor design.

6.1.03 In the event of troubles, it is important that the Operational Checks described in 6.2 through 6.6 be performed BEFORE any attempts are made to repair the test set. By following this procedure, it can be determined if the problem is real or results from improper operation of the test set.

6.1.04 If the trouble cannot be found and corrected by following the procedures of 6.2 through 6.7 reference should be made to the block diagrams of Figures 5.1 and 5.2, the circuit description of Section 5, and the detailed test procedures of Section 7. A competent technician with an understanding of the circuit functions should be able to trace signals and locate and repair any fault which may occur.

6.1.05 If local repair is not possible, it is suggested that the complete test set be returned for repair with information regarding the suspected trouble.

6.1.06 After any repairs, not made by Wilcom Products, Inc. the test set should be re-aligned. Section 7, Alignment and Calibration, describes the methods and equipment required. In most cases it will not be necessary to repeat the whole of this procedure, but only applicable portions.

6.2 Operational Checks, General

6.2.01 Location of trouble within the T195 can often be expedited by making a few simple operational tests. All of these tests can be done without removing the set from its case, and without using any test equipment except patch cords and the T195 itself. More detailed tests are described in the Alignment and Calibration section.

6.2.02 After applying power to the set (see Section 4.1) and verifying the initial conditions of Section 4.2, the Level Tracer is ready to perform the operational checks of Sections 6.3 through 6.6 to verify proper operation. If any check is not performed satisfactorily, consult REPAIR PROCEDURE, Section 6.7, for aid in isolating the probable cause of trouble.

6.2.03 The LEVEL Operational Check, Section 6.3, describes the basic send and receive functions of the Level Tracer. Should difficulty be encountered with this check, additional trouble isolation may be accomplished by

using a separate measuring set and/or generator to check the send and receive sections of the Level Tracer independently.

6.3 LEVEL Operational Check

6.3.01 This check will verify proper operation of the majority of the Level Tracer functions and controls. Proceed as follows:

1. Verify patch cord between SEND and LINE-1 terminals. TRACE 1 should be at the bottom of the CRT and TRACE 2 at the 0 dB line.

NOTE: An individual trace may be identified by using the V-POS/REF toggle switch and control to momentarily relocate the trace.

2. Push to engage — FREQUENCY RANGE Hz: 20K
3. Push to release — TRACE 1: ASSIGN INPUT; traces are coincident at 0 dB.
4. Push TRACE 1: SINGLE UPDATE; trace 1 LED goes out.
5. Set SEND dBm switches to -2 dB; trace 2 should be one graticule division from 0 dB.
6. Engage the X5, X2 and X1 VERTICAL SCALE MULTIPLIER pushbuttons individually and verify the proper deflection of trace 2 for each multiplier.
7. Engage the X10 VERTICAL SCALE MULTIPLIER pushbutton; verify trace 2 remains at 0 dB for matching settings of the RECEIVE dBm and SEND dBm switches from +19 to -49 dBm. Return both thumbwheel switches to zero settings.
8. Engage matching INPUT IMPEDANCE and SEND IMPEDANCE pushbuttons (150, 600, 900); verify trace 2 remains at 0 dB for each impedance.
9. Engage INPUT IMPEDANCE: BRDG pushbutton; verify trace 2 indicates +6 dB for each impedance as in step 8.
10. Engage the INPUT IMPEDANCE: TERM/600, and the SEND IMPEDANCE: 600, pushbuttons.
11. Engage COMPARE: L1/STD pushbutton; CRT display remains unchanged.
12. Move patch cord from LINE-1 terminals to STD terminals; trace 2 is displayed at bottom of CRT.
13. Push to release TRACE 2: ASSIGN INPUT pushbutton; trace 2 returns to 0 dB.
14. Engage COMPARE: L2/STD pushbutton; CRT display remains unchanged.

15. Engage TRACE 1: CONTINUOUS UPDATE pushbutton; trace 1 is displayed at bottom of CRT and relay switching is audible at end of each sweep.
16. Move patch cord from STD terminals to LINE-2 terminals; traces exchange positions on CRT display.
17. Engage COMPARE: L1/L2 pushbutton; traces exchange positions on CRT display.
18. Engage TRACE 1: ASSIGN INPUT pushbutton; traces are coincident at 0 dB.
19. Pushing either trace CLEAR pushbutton will clear the corresponding trace while the button is held engaged.
20. Engage the FREQ RANGE Hz: 8K and the TUNING: MAN pushbuttons. Adjust the MANUAL TUNING knob fully counter-clockwise. If necessary, adjust 0-CAL for a SEND FREQUENCY of 0 Hz.
21. Adjust the MANUAL TUNING knob fully clockwise. Observe a SEND FREQUENCY of approximately 8500 Hz.
22. Engage the FREQ RANGE Hz: 400, the TUNING: SW, the LOW FREQ REJ, and the X5 VERTICAL SCALE MULTIPLIER pushbuttons; the CRT displays a high pass characteristic: approximately -3 dB at 300 Hz, -15 dB at 180 Hz.
23. Release the LOW FREQ REJ pushbutton and engage the FREQ RANGE Hz: 8K, the VERTICAL SCALE MULTIPLIER: X10, and the FUNCTION: IMP pushbuttons. Move the patch cord from LINE-2 to LINE-1 terminals.

24. Set the B.O. CAP uF to .020.

25. Check the IMPEDANCE COMPENSATOR by observing the approximate frequency where the traces "bottom" on the CRT display.

D66 engaged: 6500 Hz

H88 engaged: 5500 Hz

D66 & H88 engaged: 4200 Hz

26. Release both IMPEDANCE COMPENSATOR pushbuttons. Set the B.O. CAP to zero. Engage the FUNCTION: LEVEL, and the TRACE 2: ASSIGN INPUT pushbuttons.

6.4 Return Loss Operational Check

6.4.01 This check will verify proper operation of the RTN LOSS function. Proceed as follows:

1. Remove the patch cord from the SEND and LINE-1 terminals. Place a jumper across the EXT NETWORK binding posts.

CAUTION

CHANGES HAVE BEEN MADE

ON THIS PAGE.

SEE ISSUE SHEET.

2. Engage the FUNCTION: RTN LOSS, the RET LOSS NET: EXT, and the VERTICAL SCALE MULTIPLIER: X1 pushbuttons. Observe a trace on the CRT display which is 0 dB $\pm$ 0.5 dB.

3. Connect a 600 ohm $\pm$ 1% resistor across the LINE-1 terminals.

NOTE: A Resistance decade box having the required accuracy may be used.

4. Replace the EXTERNAL NETWORK jumper with a 900 ohm $\pm$ 1% resistor.

5. Set the RECEIVE dBm thumbwheel to -14 dBm. Observe a trace on the CRT display which is 0 dB $\pm$ 0.5 dB.

6. Replace the EXTERNAL NETWORK 900 ohm resistor with a 500 ohm $\pm$ 1% resistor.

7. Set the RECEIVE dBm thumbwheel to -21 dBm. Observe a trace on the CRT display which is +0.2 dB $\pm$ 0.5 dB.

8. Replace the EXTERNAL NETWORK 500 ohm resistor with a 600 ohm $\pm$ 1% resistor.

9. Set the RECEIVE dBm thumbwheel to -40 dBm and engage the VERTICAL SCALE MULTIPLIER: X10 pushbutton. Observe a trace on the CRT display that is below the 0 dB line.

10. Set the RECEIVE dBm thumbwheel to zero dBm and remove the precision resistances from the LINE-1 and EXTERNAL NETWORK binding posts.

6.5 Impedance Operational Check

6.5.01 This check will verify proper operation of the IMP function. Proceed as follows:

1. Remove the patch cord, if present, from the SEND and LINE-1 terminals. Place a 900 ohm $\pm$ 1% resistor across the LINE-1 terminals.

NOTE: A resistance decade box having the required accuracy may be used.

2. Engage the FUNCTION: IMP and the VERTICAL SCALE MULTIPLIER: X1 pushbuttons. Observe a trace on the CRT display which is 900 ohms $\pm$ 55 ohms.

3. Engage the VERTICAL SCALE MULTIPLIER: X2 pushbutton. Observe a trace on the CRT display which is $\pm$ 52 ohms of the 450 ohm line.

4. Replace the 900 ohm resistor across the LINE-1 terminals with a 4500 ohm $\pm$ 1% resistor. Engage the VERTICAL SCALE MULTIPLIER: X5 pushbutton. Observe a trace on the CRT display which is $\pm$ 185 ohms of the 900 ohm line.

5. Engage the VERTICAL SCALE MULTIPLIER: X10 pushbutton. Observe a trace on the CRT display which is $\pm$ 235 ohms of the 450 ohm line.

6. Remove the precision resistance from the LINE-1 terminals and engage the FUNCTION: LEVEL pushbutton.

Noise Check *

6.6.01 This check will verify the input noise specification. Proceed as follows:

1. Remove the patch cord, if present, from the SEND and LINE-1 terminals.
2. Engage the FREQ RANGE Hz: 20K pushbutton.
3. Set the RECEIVE dBm thumbwheel to -59 dBm and the SEND dBm thumbwheel to -49 dBm.
4. Observe a trace on the CRT display below -85 dBm for the three terminated input impedances: TERM- 150, 600, 900.

6.7 Repair Procedure

6.7.01 The Operational Checks of 6.2 through 6.6 should give a good indication of trouble location. The next step is to remove the set from its case.

CAUTION: DO NOT REMOVE ANY SCREWS FROM THE FRONT PANEL.

Three covers must be removed to access all assemblies within the Level Tracer. All card cage printed circuit assemblies are accessible with the back cover removed. All other assemblies require removal of at least the top cover. Once the top cover is off, it will be readily apparent whether the bottom cover must also be removed. All covers are replaced by reversing the order of the removal procedures.

1. Back Cover Removal

- a. Disconnect the power cord from the Level Tracer and remove 10 screws which hold the back cover to the chassis.
- b. Lift out the back cover.

2. Top Cover Removal

- a. Remove 5 screws from each side of the Level Tracer.
- b. Lift the top cover straight up.

3. Bottom Cover Removal

- a. Turn the Level Tracer upside down.
- b. Remove 6 screws which hold the bottom cover to the chassis.
- c. Lift the bottom cover off the chassis.

6.7.02 A good visual inspection may give a quick solution to the problem. Look for loose connectors, solder connections or component parts which have been jarred loose or broken, or any other visual clues. Pay particular attention to areas where the operational checks have indicated trouble. Reference to Figures 6-1 thru 6-3 will help identify these areas. If the fault is not apparent at this point, detailed trouble shooting may continue as outlined in 6.1.04.

* PER WILCOM (DICK MINER) LOWER LIMIT -80dBm WITH ABERRATIONS < 3 MINOR DIV 6-3

6.7.03 Printed Circuit Assembly Removal — Removal instructions are provided for those assemblies that are not located in the card cage. Be sure the ac power cord is removed from the Level Tracer when an assembly is being removed or replaced.

1. Preamplifier and Display Scaling Assembly 015 Removal

- a. Set the Level Tracer on its side.
- b. Locate the standoff supporting the rear of the 015 assembly and remove the screw which attaches the standoff to the frame. (Figure 6-2 and 6-3 show the 015 assembly's location in the Level Tracer.)
- c. Remove the two screws which attach the 015 assembly to the front panel.
- d. Swing the 015 assembly out on its cable and insulate it from the chassis and other printed circuit assemblies.

2. Frequency and Counter Display Assembly 016 Removal

- a. Remove the 4 screws which attach the 016 assembly to the front panel. (Figure 6-2 shows the 016 assembly's location in the Level Tracer.)
- b. Swing the 016 assembly out on its cable and insulate it from the chassis and other printed circuit assemblies.

3. Sweep Oscillator Assembly 074 Removal

- a. Remove the control nut which fastens the SLOW/FAST switch to the front panel.
- b. Push the switch out of the front panel, making sure the lockwasher does not fall off.
- c. Remove the 4 screws which attach the 074 assembly to the front panel. (Figure 6-1 and 6-2 show the 074 assembly's location in the Level Tracer.)
- d. Swing the 074 assembly out on its cable and insulate it from the chassis and other printed circuit assemblies.

4. Measurement Circuit Assembly 030 Removal

- a. Remove the 4 screws which attach the 030 assembly to the front panel. (Figure 6-1 and 6-3 show the 030 assembly's location in the Level Tracer.)
- b. Swing the 030 assembly out on its cable and insulate it from the chassis and other printed circuit assemblies.

5. Control Logic 1 Assembly 011 Removal

- a. Remove the Trace 1 V-POS control knob and the Average Over Band LO FREQ adjust knob.
- b. Remove the nut from the Trace 1 V-POS REF switch.

CAUTION

**CHANGES HAVE BEEN MADE
ON THIS PAGE.
SEE ISSUE SHEET.**

- c. Push the switch out of the front panel making sure not to loose the lockwasher.
 - d. Remove the two screws which attach the 011 assembly to the front panel. (Figure 6-2 shows the 011 assembly's location in the Level Tracer.)
 - e. Swing the 011 assembly out on its cable and insulate it from the chassis and other printed circuit assemblies.
6. Control Logic 2 Assembly 012 Removal.
 - a. Remove the Trace 2 V-POS control knob and the Average Over Band HI FREQ adjust knob.
 - b. Remove the nut from the Trace 2 V-POS REF switch.
 - c. Push the switch out of the front panel making sure not to loose the lockwasher.
 - d. Remove the two screws which attach the 012 assembly to the front panel. (Figure 6-2 shows the 012 assembly's location in the Level Tracer.)
 - e. Swing the 012 assembly out on its cable and insulate it from the chassis and other printed circuit assemblies.
 7. Input and Power Amplifier Assembly 014 Removal.
 - a. Remove the Preamplifier and Display Scaling Assembly 015.
 - b. Remove the two screws located on the back right and left corners of the 014 assembly.
 - c. Remove the four screws which attach the 014 assembly to the front panel. (Figures 6-1 & 6-3 show the 014 assembly's location in the Level Tracer.)
 - d. Turn the set on its side and remove the Amp connectors.
 - e. Exercise caution to avoid damaging wiring insulation during removal.
 - f. Reconnect Amp connectors to 014 assembly.
 - g. Insulate the 014 assembly from the chassis and other printed circuit assemblies.
 8. Power Supply Assembly 018 Removal.
 - a. Loosen the set screws holding the pot shafts of the FOCUS and INTENSITY controls.
 - b. Remove the screw and nut which attach the plexiglass cover to the power supply assembly 018. (Figure 6-1 shows the 018 assembly's location in the Level Tracer.)
 - c. Remove the 7 screws attaching the board to the Level Tracers chassis.
 - d. Lift side of 018 assembly opposite the wiring connections. Insulate board well from the chassis and other printed circuit assemblies.

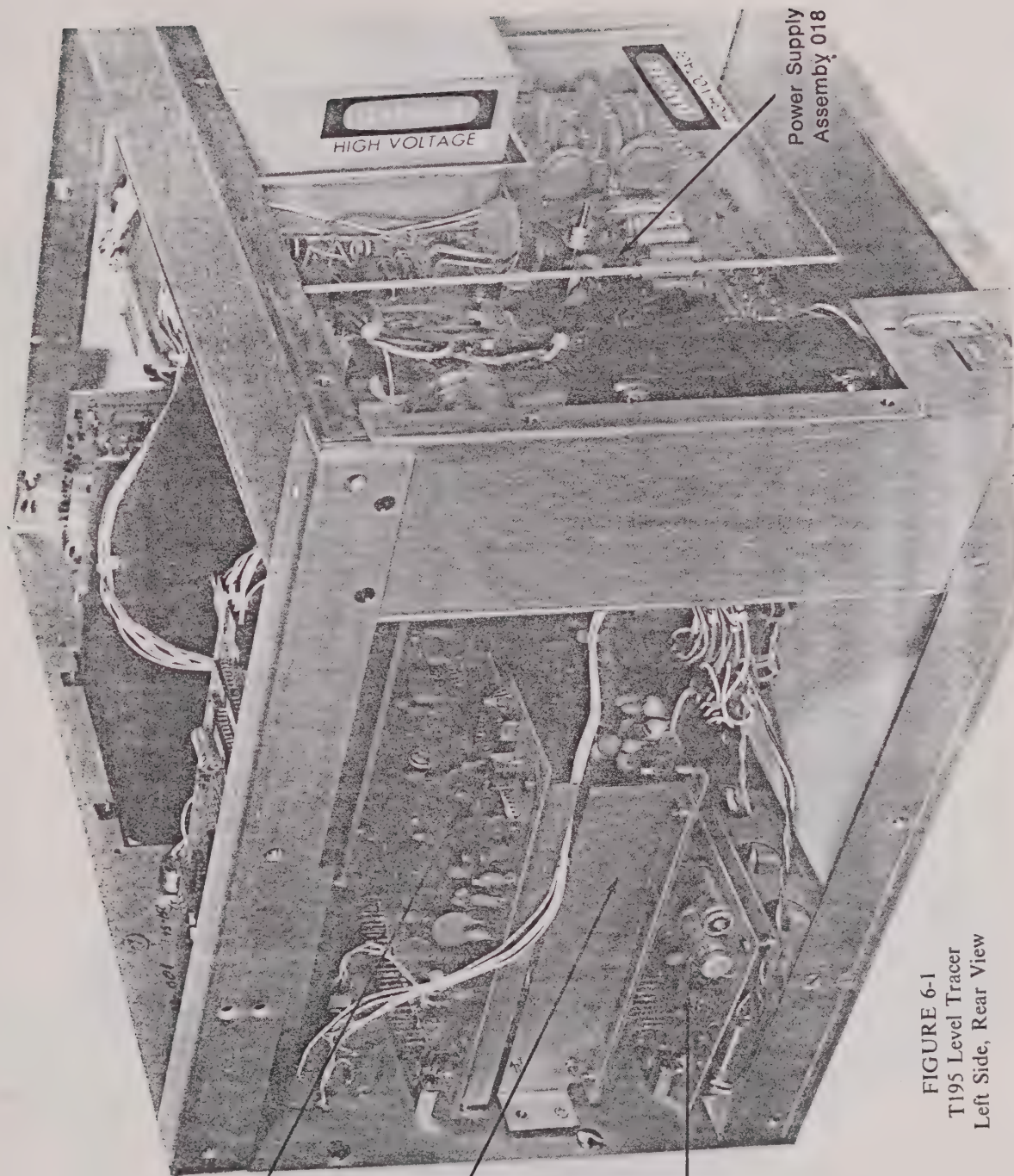


FIGURE 6-1
T195 Level Tracer
Left Side, Rear View

Sweep
Generator
Assembly 074

Measurement
Circuit
Assembly 017

Input and
Power Amplifier
Assembly 014

Power Supply
Assembly 018

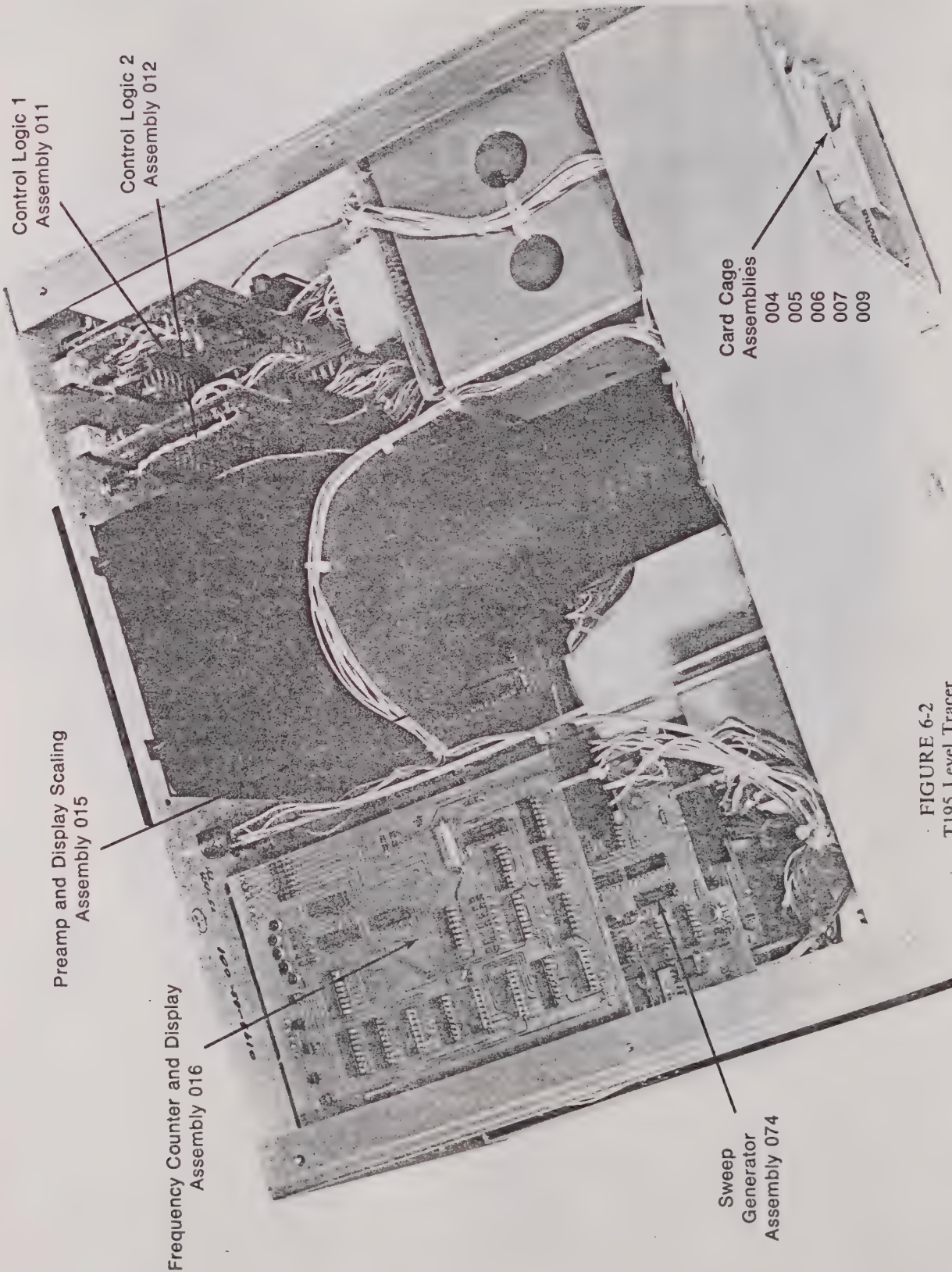


FIGURE 6-2
T195 Level Tracer
Top View

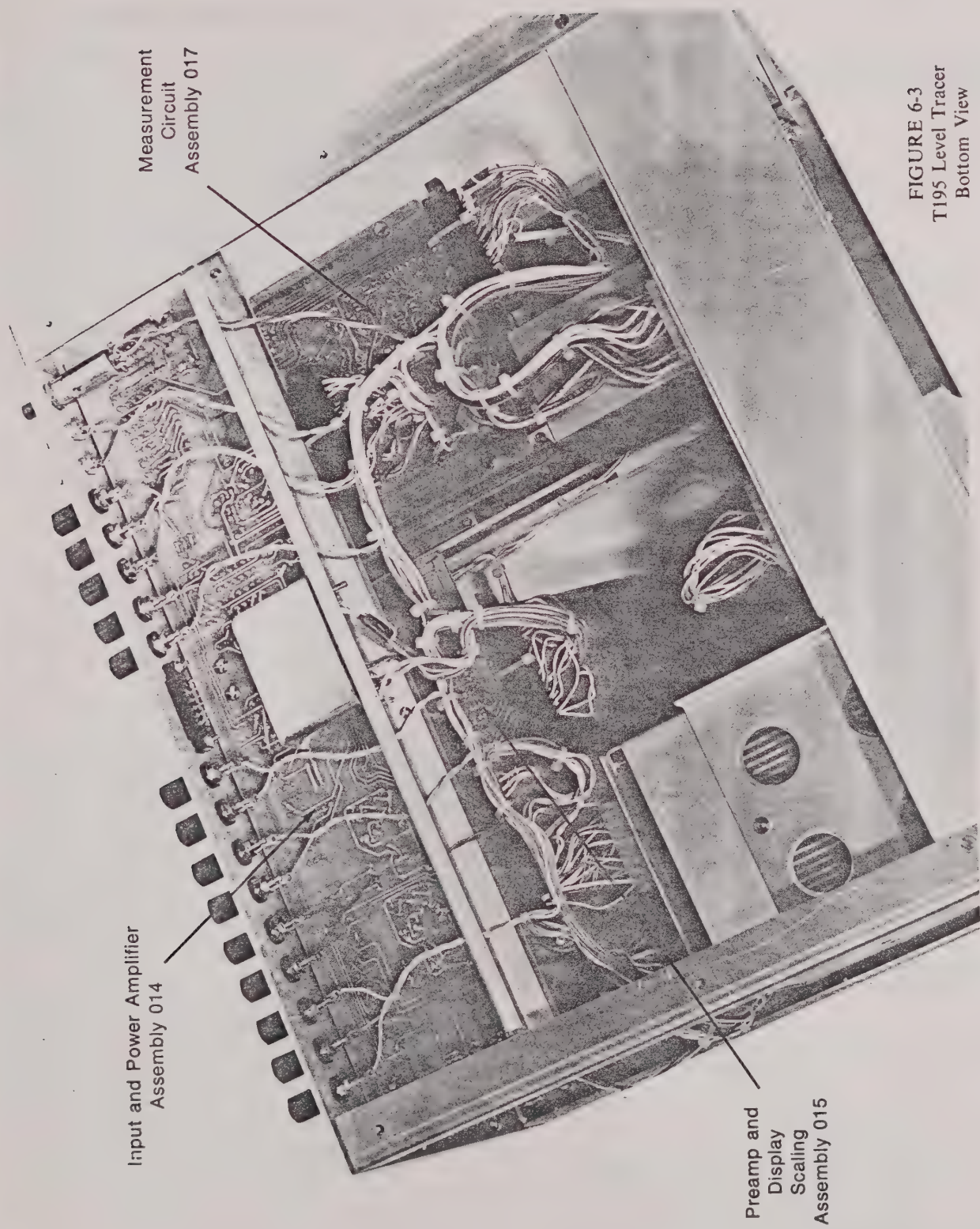


FIGURE 6-3
TI95 Level Tracer
Bottom View

7.0 ALIGNMENT AND CALIBRATION

7.1 General

7.1.01 This section provides information needed to align the Model T195 Level Tracer. Test information verifies the proper operation of the Level Tracer. Alignment information covers adjustments which can be made by field personnel, using standard test equipment.

7.1.02 The Operational Checks in Section 6 should be performed BEFORE any attempt is made to calibrate the Level Tracer. Malfunctions uncovered by the Operational Checks should be repaired prior to completion of the alignment procedure.

7.1.03 An alignment check list should be completed during the alignment procedure.

7.2 Equipment Required

1. Electronic ac voltmeter or Level Meter accurate to within $\pm .1$ dB from 20 Hz to 20 kHz.
2. General purpose oscilloscope.
3. Digital multimeter.
4. Decade resistor - 0 to 10 k ohms, .1%.
5. Frequency counter - 400 k Hz capability.
6. Sweep Generator - 20 K Hz to 20 K Hz.
7. dc Power Supply 48V at 50 mA.

7.3 General Procedure

7.3.01 Applying Power - To eliminate repetitive instructions, it is assumed that power will be removed from the Level Tracer during all disassembly or assembly operations and reapplied prior to testing. Allow 5 minutes for circuits to stabilize each time power is applied.

7.3.02 For alignment purposes, the T195 is removed from its case, (See Section 6.7.01). A card extender is provided for ease of access to the card cage printed circuit assemblies. Removal of other printed circuit assemblies is explained in Section 6.7.03.

7.3.03 Varying degrees of manual dexterity are required to perform the adjustments in this section. A visual inspection of the individual subassembly for each section should indicate where removal of the subassembly is required.

7.3.04 Make the alignment adjustments only when specified tolerances are not met. When a prescribed adjustment does not make performance satisfactory, a malfunction is probably present on the assembly being adjusted or an input signal to the assembly is faulty.

7.4 Power Supplies

7.4.01 With the T195 operating, use a dc voltmeter to check the following voltages at the indicated circuit points on the 018 assembly.

1. +18 V dc
 - Check U2 Pin 4 for $+18 \pm 1$ V dc
 - Check E11 for $+18 \pm 1$ V dc
2. 14 V dc Check
 - Check J1 Pin (s) 12, 13, 14, for $+14.00 \pm .1$ V dc
 - Check J1 Pin (s) 9, 10, 11 for $-14.00 \pm .1$ Vdc
 - Insure $+14.00$ and -14.00 are within .05 V dc of each other.
3. 80 V dc Check
 - Check J25 Pin (s) 13, 15, for -80 V dc ± 5 V
 - Check J25 Pin (s) 9, 11, for 80 V dc ± 5 V
4. +5 V dc Check
 - Check J1 Pin 15 for $+5.00 \pm .3$ V dc

7.4.02 Checking the high voltage requires caution and should be done only when a malfunction is suspected in the circuit - not a routine functional check.

1. Using a multimeter capable of 3000 Vdc or higher, check the following voltages:

- a. Measure -2250 ± 250 Vdc between E7 and chassis ground.
- b. Measure $6.3 \pm .3$ Vdc between E1 (+) and E14(-). This voltage is displaced from ground by the high voltage.

7.5 Line Switching Circuit Checks

1. Connect a jumper between the two Dial posts.
2. Press to engage the Line 1 Dial pushbutton.
3. Measure less than 10 ohms between the LINE 1 terminal with the digital multimeter.
4. Measure greater than 10 megohms between each LINE 1 terminal and GND with the digital multimeter.
5. Press the LINE 2 DIAL pushbutton and see that it cannot be engaged.
6. Press to release the LINE 1 DIAL pushbutton.
7. Press to engage the LINE 2 DIAL pushbutton.
8. Measure less than 10 ohms between the LINE 2 terminals with the digital multimeter.
9. Measure greater than 10 megohms between each LINE 2 terminal and GND with the digital multimeter.

10. Press to engage the SEND DIAL pushbutton.
11. Measure greater than 10 megohms between the LINE 2 T & R terminals with the digital multimeter.
12. Measure less than 10 ohms between the SEND R and SEND T terminals with the digital multimeter.
13. Measure greater than 10 megohms between the SEND R, SEND T and GND terminals with the digital multimeter.
14. Press to release the LINE 2 DIAL and SEND DIAL pushbuttons.
15. Remove the jumper from between the DIAL posts.

7.6 Hold Circuits

7.6.01 There is no calibration required. Hold circuit criteria are:

- a. Must draw sufficient dc current to hold the line, with dc applied in either polarity. The T194 hold circuits will draw at least 25 mA when 48 volt battery is applied through 1200 ohms resistance or 24 volt battery is applied through 400 ohms.
- b. Must have insertion loss limits compatible with test set accuracy over the specified frequency range.
- c. Must cause no distortion or signal clipping at the maximum signal voltage level to which it will be subjected.

7.7 Deflection Amplifier

7.7.01 All adjustments in this section are located on the Deflection Amplifier Assembly (007) located in the card cage assembly.

1. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1. *P - 4, /*
2. Press to engage the POWER pushbutton.
3. Install patch cord between LINE 1 and SEND terminals.
4. Adjust the INTENSITY, FOCUS, and ASTIG knobs for a well defined trace along the zero dB reference line. The input relay switching between traces should be audible.
5. Calibrate the HOR POS as follows:
 - a. Engage the TUNING: MAN pushbutton and turn the MANUAL TUNING knob fully counterclockwise.
 - b. Adjust the screwdriver O-CAL control for zero SEND FREQUENCY
 - c. Adjust the MANUAL TUNING knob for a SEND FREQUENCY of 4000 Hz.

- d. Adjust the HOR POS knob to center the frequency maker.
6. Adjust horizontal gain pot R19 to align end of CRT trace behind righthand vertical line of graticule.
7. Adjust marker amplitude pot R17 for a frequency marker height equal to one CRT graticule division.
8. Remove patch cord; Engage TUNING: SW and FUNCTION: IMP pushbuttons.
9. Press Trace 2 SINGLE UPDATE; after completion of sweep press Trace 2 CLEAR.
10. Adjust vertical position reference pot R11 to align ~~button~~ trace behind -30 dB graticule line.
11. Adjust vertical gain pot R12 to align trace behind +10 dB graticule line.
12. Rotate the HOR POS control to check for a trace movement of about one-half inch in both directions and recenter the control.

7.8 Tracking Analog Digital Converter

7.8.01 All adjustments in this section are located on the Analog to Digital Converter Assembly (006) located in the card cage assembly.

1. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1.
2. ~~Turning~~ switch to MAN
3. Frequency range 4 k
4. Manual tuning pot to minimum (counterclockwise)
5. Adjust front panel "O-CAL" to read zero Hz ± 2 on frequency display.
6. Increase the MANUAL TUNING knob while visually observing the marker across the CRT and stop at exactly the time the marker physically reaches the end of the trace. Read the frequency display at 4000 ± 10 Hz.
7. If not at 4000 ± 10 Hz, then adjust the pot R41 on the A/D board (006).
8. Between approximately 3992 Hz and 4008 Hz the analog to digital converter will produce the same digital value. For this reason, the MANUAL TUNING knob should be "rocked" back and forth to verify the actual end of the trace.

7.9 Sweep Generator

7.9.01 All adjustments in this section are located on the Sweep Oscillator Assembly (074) located behind the FREQUENCY RANGE and TUNING pushbutton.

1. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1.
2. Press to engage the MAN TUNING pushbutton.

4a. Press each frequency range pushbutton. If deviation is within limits, proceed to step 11. If not, continue with steps.

3. Press to engage the 400 Hz FREQ RANGE pushbutton.

4. Turn front panel manual tuning pot to minimum.

CAUTION

Do not adjust temperature compensating control R41.

5. Adjust R43 for zero on frequency display readout.

6. Monitor TP2 and adjust R59 for 0 ± 100 mV dc offset. Repeat steps 5 & 6 until both conditions are satisfied.

7. Turn the O-CAL pot clockwise until it clicks. (FREQ stops changing)

8. Adjust R43 for 135 Hz on frequency display readout.

9. Adjust O-CAL pot for 0 Hz on frequency display readout.

10. Depress each of frequency range and observe no more than 30 Hz devert. Note: Pot has an adjustment range of approximately 280 Hz.

11. Connect a patch cord between SEND terminals and an accurate level meter providing a 600 ohm termination. Engage FREQ RANGE Hz, 4 k pushbutton and set SEND FREQUENCY to 2000 Hz.

12. Adjust level meter for an on scale reading.

13. Adjust tuning pot R13 for maximum level. Note: It is very important that this is adjusted for exactly peak signal.

14. Measure $0 \pm .01$ dBm with a level meter set at 600 ohm terminating. Adjust level pot R5 if necessary.

15. Switch level meter to 600 ohm bridging. Reading should increase $6 \text{ dB} \pm .1 \text{ dB}$.

16. Measure the frequency at SEND T and R with a frequency counter. Adjust the MANUAL TUNING control until the measured frequency is approximately 2000 Hz. The SEND FREQUENCY display shall read the same as the frequency counter, plus or minus five Hz.

17. Sweep limit adjustment. Monitor TP3 for +14 VDC level. Increase front panel manual tuning pot until +14 VDC level drops to less than 4 VDC. Frequency display should read $4250 \pm 10 \text{ Hz}$. Adjust sweep limit pot R 98 as required.

18. Depress the frequency range switch "20 k". Adjust the manual tuning knob for approximately 2 k Hz. Level through the entire frequency range 30 Hz to 20 k Hz there should be no more than $\pm .2 \text{ dB}$ level variation over the entire band. R28 affects the output flatness from approximately 10 k to 20 k, adjust for best compromise.

19. Note the response of the level tracers receive section to the previous step. The response should be .2

dB (taking into account the send level flatness). Note: You may again adjust R28 for best compromise between send level and receive response.

20. Engage 2600 SKIP and the FREQ RANGE Hz, 4 k pushbuttons.

21. Adjust manual tuning control until level drops off. Note and record reading of SEND FREQUENCY display.

22. Continue adjusting manual tuning control until level reappears. Note and record frequency.

23. The difference of these two frequencies should be $300 \text{ Hz} \pm 10 \text{ Hz}$. If not adjust R83 (CW Wider CCW Narrower). Return to Step 22.

24. The low cutoff frequency should be $2450 \text{ Hz} \pm 10 \text{ Hz}$. If not adjust R76. Check Hi frequency cutoff for $2750 \pm 10 \text{ Hz}$.

25. Release 2600 SKIP button.

7.9.02 Send Attenuator and Termination Check

1. Adjust the MANUAL TUNING knob for a send frequency of 2000 Hz.

2. The level meter should read $0.00 \pm .02 \text{ dBm}$. Adjust R5 if necessary to obtain required accuracy.

3. Adjust the SEND dBm thumbwheel 1 dB switch through all ten 1 dB steps. The 1 dB steps indicated on the level meter should deviate no more than 0.1 dB between adjacent steps and the maximum deviation over the entire range shall be no more than 0.5 dB.

4. Adjust the SEND dBm thumbwheel 10 dB switch through all seven steps. The 10 dB steps indicated on the level meter should deviate no more than 0.1 dB between adjacent steps and the maximum deviation over the entire range shall be no more than 0.2 dB.

5. Return the SEND dBm thumbwheel switches to -0.0 dBm .

6. Terminate the level meter with 900 ohms.

7. Engage the SEND IMPEDANCE 900 pushbutton. The level meter should read $0.00 \pm .1 \text{ dBm}$ (900 ohms).

8. Set the level meter to 900 ohm bridging. The reading should increase $6 \text{ dB} \pm .1 \text{ dB}$.

9. Repeat steps 6 thru 8 for the 150 ohm SEND IMPEDANCE.

10. Engage the SEND IMPEDANCE 900 pushbutton and set the dBm thumbwheel switches to +19 dBm.

11. Observe an undistorted sine wave at the SEND terminals.

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12. Engage the FUNCTION, IMP pushbutton. The sine wave is no longer present at the SEND terminals.
13. Engage the FUNCTION, RTN LOSS pushbutton. The sine wave does not appear at the SEND terminals.
14. Engage the FUNCTION, LEVEL pushbutton. The sine wave is present at the SEND terminals.

7.10 Measurement Circuit

7.10.01 All adjustments in this section are located on the Measurement Circuit Assembly (017) located behind the RECEIVE dBm, B.O. CAP, and SEND dBm controls.

7.10.02 Frequency Translator

1. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1.
2. Connect the test oscillator through a precision 600 ohm resistance to the LINE I terminals of the T195. Set the oscillator for a frequency of 2000 Hz.
3. Connect an accurate ac voltmeter across the oscillator output and adjust the oscillator level so that the voltmeter reads 1.549 volts (+6 dBm 600 ohms).

Note: To avoid errors due to hook-up lead resistance, the precision resistor should be located at the LINE A terminals, and the ac voltmeter should be connected as close to the resistor as possible.

Note: For a balanced input signal, the precision resistor would be split, 300 ohms in each side of the line. However, most ac voltmeters used in calibration are single ended. Therefore, calibration is normally performed with the precision resistor in series with one side of the line and the other side grounded.

Note: Calibration accuracy in all cases (except N-G) is specified in terms of input power, not voltage. (For bridging measurements, this is power into an external termination.) This is the reason for monitoring input voltage ahead of a precision series resistor. The measured voltage should be precisely twice the calculated voltage for a specified level. Thus 0 dBm, 600 ohm is .7746 volts, and the ac voltmeter reading ahead of the series resistance for this level is 1.5492.

4. Release the TRACE 1, ASSIGN INPUT pushbutton.
5. Adjust R45 for an even amplitude sine wave as observed on an oscilloscope at U8 pin 6.

Note: The sine wave observed in steps 5 and 6 is chopped at a 100 k Hz rate.

6. Adjust R51 for a clean even amplitude sine wave as observed on an oscilloscope at U9 pin 6.
7. Adjust R66 for equal amplitude sine waves at U8 pin 6 and U9 pin 6 as observed on an oscilloscope.

7.10.03 Detector and Scaling

1. Analog scale adjustment

- a. Monitor TP2 with a dc voltmeter and adjust R83 for +1.000 V. (-0 dBm 600 ohms, ac voltmeter reads 1.549 volts.)
- b. Set oscillator level for an ac voltmeter reading of .049 volts. (-30 dBm 600 ohms) Monitor TP2 and adjust R75 for +31.6 mV.
- c. Again check +1.000 at -0 dBm, adjust R83 if necessary. (Step a.)
- d. Set oscillator level for an ac voltmeter reading of .0155 volts (-40 dBm). "Fine tune" adjustments R45 and R51 to achieve the lowest possible dc voltage at TP2 (10.5 mV $\pm$ 1.5 mV).
- e. Repeat steps c and d.

2. Linearity

- a. Monitor TP2 and adjust the oscillator level to check detector linearity.

ac voltmeter reading		TP2 voltage
4.898 V	+10	3.16 V dc $\pm$.05 V dc
1.549 V	+10	1.000 V dc $\pm$.015 V dc
1.549 V	-00	1.000 V dc $\pm$.003 V dc
.4898 V	-10	.316 V dc $\pm$.005 V dc
.1549 V	-20	100 m V dc $\pm$ 2.5 m V dc
.049 V	-30	31.6 m V dc $\pm$ 2.0 m V dc
.01549 V	-40	10.5 m V dc $\pm$ 1.5 m V dc

7.10.04 Receive Attenuator and Termination Check

1. Monitor TP2 and the test oscillator output. Adjust the oscillator level and the RECEIVE dBm thumbwheel over the 1 dB step attenuator range. For identical levels, the voltage at TP2 should deviate no more than 120 m V dc between adjacent steps and no more than 240 m V dc over the entire range.

ac voltmeter reading	RECEIVE dBm
1.549 V	0
1.381 V	1
1.230 V	2
1.097 V	3
.9774 V	4
.8711 V	5
.7763 V	6
.6919 V	7
.6167 V	8
.5496 V	9

- Monitor TP2 and the test oscillator output. Adjust the oscillator level and the RECEIVE dBm thumbwheel over the 10 dB step attenuator range. For identical levels, the voltage at TP2 should deviate no more than 120 mV dc between adjacent steps and no more than 240 mV dc over the entire range.

ac voltmeter reading	RECEIVE dBm
4.898 V	+10
1.549 V	+00
1.549 V	-00
.4898 V	-10
.1549 V	-20
.049 V	-30
.0155 V	-40
.0049	-50

- Replace the precision 600 ohm resistor at the LINE 1 terminals with a 900 ohm precision resistor.
- Engage the INPUT IMPEDANCE: 900 pushbutton and adjust the oscillator level for an ac voltmeter reading of 1.897.
- Move the high impedance ac voltmeter to the LINE 1 terminals of the Level Tracer. The voltmeter should read ~~.7746~~ ^{.948} ac ± 74 mV ac.
- Return the ac voltmeter to the oscillator output and replace the precision 900 ohm resistor with a 150 ohm precision resistor.
- Engage the INPUT IMPEDANCE, 150 pushbutton and adjust the oscillator level for an ac voltmeter reading of .7746 volts.
- Move the ac voltmeter to the LINE 1 terminals of the Level Tracer. The voltmeter should read .3873 V ac ± 38 mV ac.

7.11 Preamp and Display Scaling

7.11.01 All adjustments in this section are located on the Preamp and Display Scaling Assembly (015) located below the CRT.

7.11.02 Log Converter

- Set all front panel controls in accordance with initial conditions of Section 4.2.01, Step 1.
- Release the TRACE 1, ASSIGN INPUT pushbutton and engage the X1 VERTICAL SCALE MULTIPLIER.
- Connect the test oscillator through a precision 600 ohm resistance to the LINE 1 terminals of the T195.
- Connect an accurate ac voltmeter across the oscillator level so that the voltmeter reads 1.549 volts (6 dBm 600 ohms).
- Adjust the test oscillator for a 2000 Hz frequency.
- Measure approximately -5.25 V dc at TP3 with a

dc voltmeter. Adjust R32 to position the CRT trace behind the 0 dB graticule line.

- Adjust the oscillator level for an ac voltmeter reading of .049 volts (-30 dBm, 600 ohms). Engage the X10 VERTICAL SCALE MULTIPLIER.
- Measure 0.0 ± 0.2 V dc at TP3. If necessary, adjust R41 to obtain correct measurement. CRT trace should be at the -30 dB graticule line.
- Set dBm thumbwheel to -00 dBm.
- Repeat steps 6 thru 9 until it is not necessary to adjust either R32 or R41 to obtain the desired results.
- Engage the X1 VERTICAL SCALE MULTIPLIER.
- Increase the test oscillator level 1 dB and observe approximately -7.0 V dc at TP 3. The CRT trace appears at ~~1~~ ^{+1 dB} dB graticule.
- Decrease the test oscillator level 1 dB and observe approximately -3.5 V dc at TP3. The CRT trace appears at -1 dB graticule.
- Decrease the test oscillator level 1 dB and observe approximately -1.75Vdc at TP3. The CRT trace appears at -2 dB graticule.
- Decrease the test oscillator level 1 dB and observe approximately 0.0 V dc at TP 3. The crt trace appears at -3 graticule.

7.11.03 Low Frequency Reject

- Remove the test oscillator and precision resistor. Install a patch cord between the SEND and LINE 1 terminals.
- Engage the following pushbuttons:

TUNING: SW
FREQ RANGE Hz: 400
VERTICAL SCALE MULTIPLIER: X10
LOW FREQ. REJ.

- Observe trace at 200 Hz is -13 dB ± 3 dB.
- Engage VERTICAL SCALE MULTIPLIER: X1
- Observe trace at 300 Hz is -2 dB ± 1 dB.
- If the above readings are out of tolerance, adjust R15 and recheck.
- Release the LOW FREQ REJ. pushbutton.

7.11.04 Impedance Calibration

- Remove the patch cord between the SEND and LINE 1 terminals; install decade resistor across the LINE 1 terminals.
- Engage the following pushbuttons:

FUNCTION: IMP
FREQ RANGE Hz: 4 k
VERTICAL SCALE MULTIPLIER: X1

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3. Set decade resistor to 500 ohms and adjust Impedance Cal Pot R43 for trace position of 500 ohms ± 20 ohms.
4. Engage the VERTICAL SCALE MULTIPLIER: X2 and set decade resistor to 1000 ohms. Observe a trace reading of 1000 ohms.
5. Engage the VERTICAL SCALE MULTIPLIER: X5 and set decade resistor to 2500 ohms. Observe a trace reading of 2500 ohms ± 375 ohms.
6. Engage the VERTICAL SCALE MULTIPLIER: X10 and set decade resistor to 5000 ohms. Observe a trace reading of 5000 ohms ± 1000 ohms.
7. Remove the decade resistor and connect a patch cord between the EXTERNAL NETWORK and LINE 1 terminals.
8. Engage the FUNCTION: IMP and AVERAGE OVER BAND pushbuttons.
9. Set the B.O. CAP thumbwheels to .050.
10. Adjust the LO FREQ BAND LIMIT control fully counterclockwise and the HI FREQ BAND LIMIT control fully clockwise.
11. Observe that trace 1 is a hyperbola (characteristic of the impedance of a capacitor versus frequency) and trace 2 is a straight line measuring 3000 300 ohms.

7.12 The alignment portion of the procedure is complete at this point. The following steps verify accuracy and function for those portions of the Level Tracer that do not require calibration adjustments or are not checked during the Operational Checks in Section 6.

1. Frequency Response and TUNING: TRACK Check

- a. Set all front panel controls in accordance with initial conditions of Section 4.2.01, Step 1.
- b. Engage the TUNING: TRACK, FREQ RANGE Hz: 20 k and VERTICAL SCALE MULTIPLIER: X1 pushbuttons. Release the TRACE 1 ASSIGN INPUT pushbutton.
- c. Connect the 0 to 20 k Hz sweep oscillator through a precision 600 ohm resistor to the LINE 1 terminals of the Level Tracer.
- d. Connect an ac voltmeter at the oscillator output and adjust the oscillator level for a voltmeter reading of 1.549 V ac $\pm .005$ V ac over the sweep range of 20 Hz to 20 k Hz.

Note: If a sweep oscillator of the required accuracy is not available, a variable frequency oscillator may be used. The oscillator frequency may be manually tuned over the frequency range of 20 Hz to 20 k Hz.

- e. Observe the frequency marker tracking the test oscillator frequency, and the SEND FREQUENCY display reading the sweep generator frequency. Trace 1 displays a 0 dB .2 dB level.

f. Engage the VERTICAL SCALE MULTIPLIER: X10 pushbutton.

- g. Reduce the level of the test oscillator until the frequency marker fails to track the oscillator frequency. The ac voltmeter should indicate less than .049 Vrms.

2. B.O. CAP uF Check

- a. Connect a capacitance meter to the EXTERNAL NETWORK terminals.
- b. Set the B.O. CAP thumbwheels to 000 and verify that both IMPEDANCE COMPENSATOR pushbuttons are released.
- c. Rotate tenth microfarad thumbwheel through its range and measure the capacitance at each step to be equal to the thumbwheel setting $\pm 1\%$.
- d. Set B.O. CAP thumbwheels to 000.
- e. Rotate hundredth microfarad thumbwheel through its range and measure the capacitance at each step to be equal to the thumbwheel setting $\pm 1\%$.
- g. Rotate thousandth microfarad thumbwheel through its range and measure the capacitance at each step to be equal to the thumbwheel setting $\pm 1\%$.

3. Recorder Output Check

- a. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1.
- b. Connect a patch cord between the SEND and LINE 1 terminals.
- c. Release the trace 1 ASSIGN INPUT pushbutton and engage the TUNING: MAN pushbutton.
- d. Adjust the MANUAL TUNING control for a SEND FREQUENCY of 2000 Hz.
- e. Using a dc voltmeter, measure 3.76 V dc $\pm .1$ V dc between the RECORDER Y terminal and GND.
- f. Observe the voltage between the RECORDER X terminal and GND while adjusting the MANUAL TUNING control through its range. The voltage should vary from 0 to ± 5.5 V dc $\pm .5$ V dc.

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TRACE ROTATION POT LOCATED
IN BACK UP. RIGHT CORNER OF UNIT

T195 Level Tracer Check List

Date Started _____
Date Completed _____

Serial Number _____
Technician _____

4.0 Initial Power up procedure

- A. Power switch lamp _____
- B. Frequency Display _____
- C. Intensity _____
- D. Focus _____
- E. Astigmatism _____
- F. Horizontal position _____
- G. Frequency Marker _____
- H. Trace rotation _____
- I. Display segment _____
(equal brightness)
- J. Level Trace _____
- K. Imp Trace _____

7.4 Power Supply (018)

- A. Record
 - 1. +18 Vdc $\pm$ 1 _____ Vdc
 - 2. -18 Vdc $\pm$ 1 _____ Vdc
 - 3. +5 Vdc $\pm$.3 _____ Vdc
 - 4. +80 Vdc $\pm$ 5 _____ Vdc
 - 5. -80 Vdc $\pm$ 5 _____ Vdc
- B.
 - 1. -14 Vdc $\pm$ 1 _____ Vdc
 - 2. +14 Vdc $\pm$.1 _____ Vdc
- C. CRT High Voltage
 - 1. 6.3 Vdc $\pm$.3 _____ Vdc

6.4 Return Loss

- A. Compromise Net
 - 1. 600 ohm
 - 2. 900 ohm
- B. Zero dB return
- C. Comparison
 - 1. 600 & 900 14.0 dB
 - 2. 600 & 500 approx. 21.0 dB

7.7 Deflection Amplifier (007)

- A. Preliminary approximate setup
 - 1. Adjust front panel zero cal _____
 - 2. Adjust oscillator, tune pot (R11) _____
 - 3. Adjust oscillator level pot (R6) _____
 - 4. Adjust translator analog scale pot (R83) _____
- B. Horizontal gain (R19) _____
- C. Vertical reference position gain (R11) _____
- D. Vertical gain (R12) _____
- E. Marker height (R17) _____
- F. Check front panel horizontal position _____

7.8 A/D Converter (006)

A. Frequency scale adjust

1. 4 k range for 4000 ± 10 cycles _____

B. Check Frequency Linearity

1. Zero Hz _____
2. 1000 Hz _____
3. 2000 Hz _____
4. 3000 Hz _____

7.9 Generator (074)

- A. Zero cal adjust
- B. Manual tune pot minimum
- C. Adjust oscillator frequency for zero (R43)
- D. Adjust 0 dc offset (R59)
- E. Adjust tuning pot for maximum amplitude (R13)
- F. Adjust level for .00 dB (R5)
- G. Adjust sweep limit (R98)

1. 4 k range for 4250 10 Hz _____

H. Adjust "25 K C Corner" (R28)

1. Adjust 2600 skip (300 cycles) _____

1. 2600 Hz (R76) _____

2. Width (R83) _____

J. Check X1 20 kHz Level Tracer

7.9.02

1. 10 dB steps _____
2. 1 dB steps _____

7.10 Translator (017)

A. Balance modulator #1 (R45)

B. Balance modulator #2 (R51)

1. With no inputs monitor TPI and fine tune R45 and R51 for best null _____

C. Adjust gain modulator #2 (R66)

D. Analog scale adjust (R83)

E. Offset balance adjust (R75)

F. Record voltages:

1. +10 dB (3.16 Vdc) _____ Vdc
2. + 0 dB (1.00 Vdc) _____ Vdc
3. - 0 dB (1.00 Vdc) _____ Vdc
4. -10 dB (.316 Vdc) _____ Vdc
5. -20 dB (100 mV) _____ mV
6. -30 dB (31.6 mV) _____ mV
7. -40 dB (10.5 mV) _____ mV

7.11 Display scaling (015)

A. 0 dB cal (R32)

B. -30 dB cal (R41)

C. Low frequency reject (R15)

D. Impedance cal (R43)

1. X1 500 ohms _____

2. X2 1 k ohms _____

3. X5 2.5 k _____

4. X10 5 k ohm _____

E. 900 ohm level shifter (Q5)

7.12-1

A. 0 dB 20 Hz - 20 k Hz

B. Record data cutoff (-30 dB) _____ dB

C. Record frequency cutoff (approx. -40 dB) _____ dB

D. Remove input & check for Frequency display less than zero Hz _____

7.12-2 Build out capacitor

1. .001 steps _____
2. .010 steps _____
3. .100 steps _____

8.0 SCHEMATIC AND LAYOUT DRAWINGS

8.1 General

8.1.01 The following pages provide the illustrations useful in locating and identifying the various assemblies that make up the Model T195 Level Tracer.

8.1.02 The necessary schematic diagrams and layout drawings of each sub-assembly are given to allow identification of various components, controls and terminals on the circuit boards. This information will be useful to those with the facilities to provide maintenance and calibration of this test equipment.

8.1.03 This section contains Figures 8-1 through 8-30. The titles of these figures are given in Table of Contents.

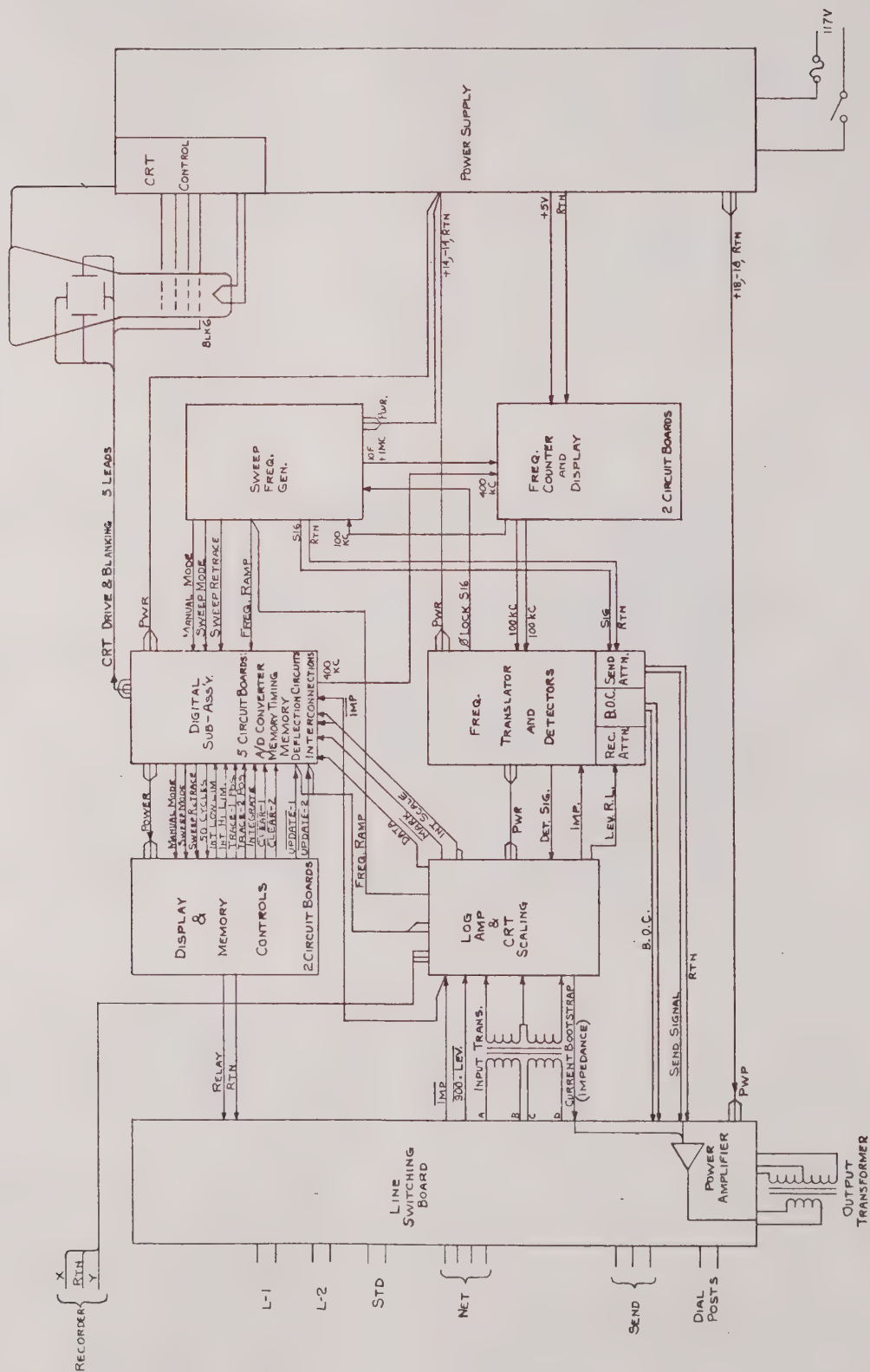


FIGURE 8-1
O/A T195 Level Tracer

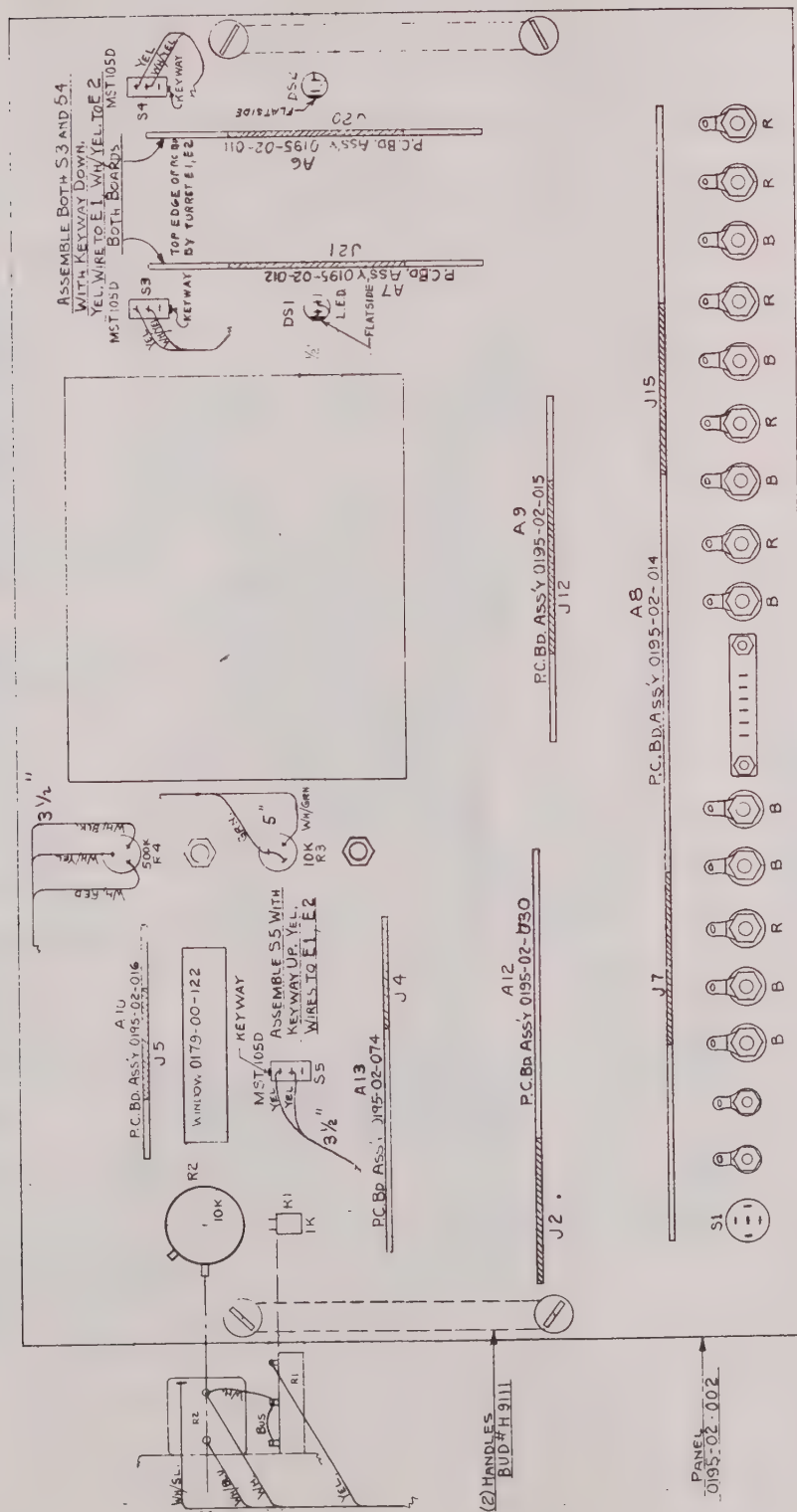
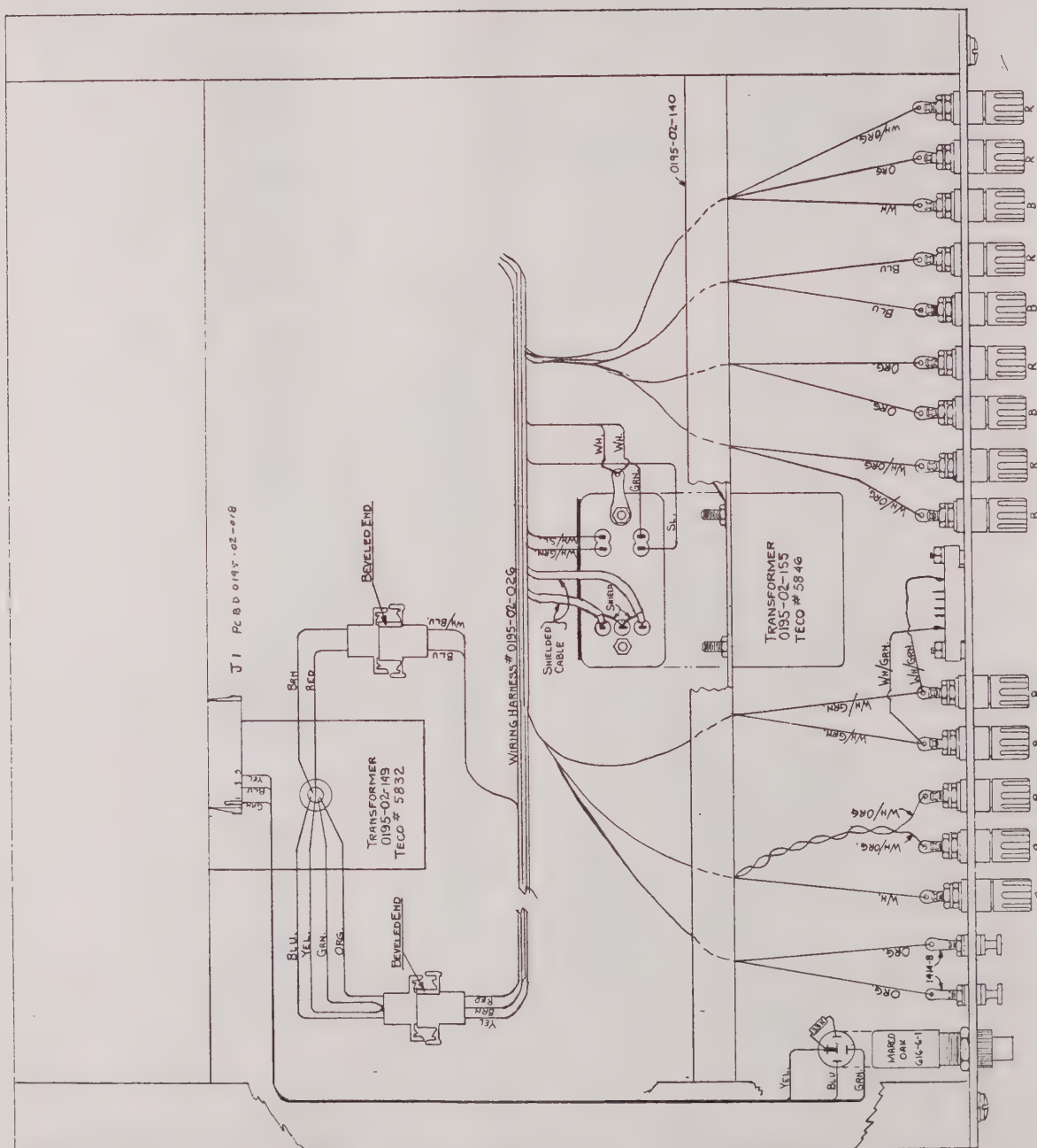


FIGURE 8-2
Front Panel Assembly





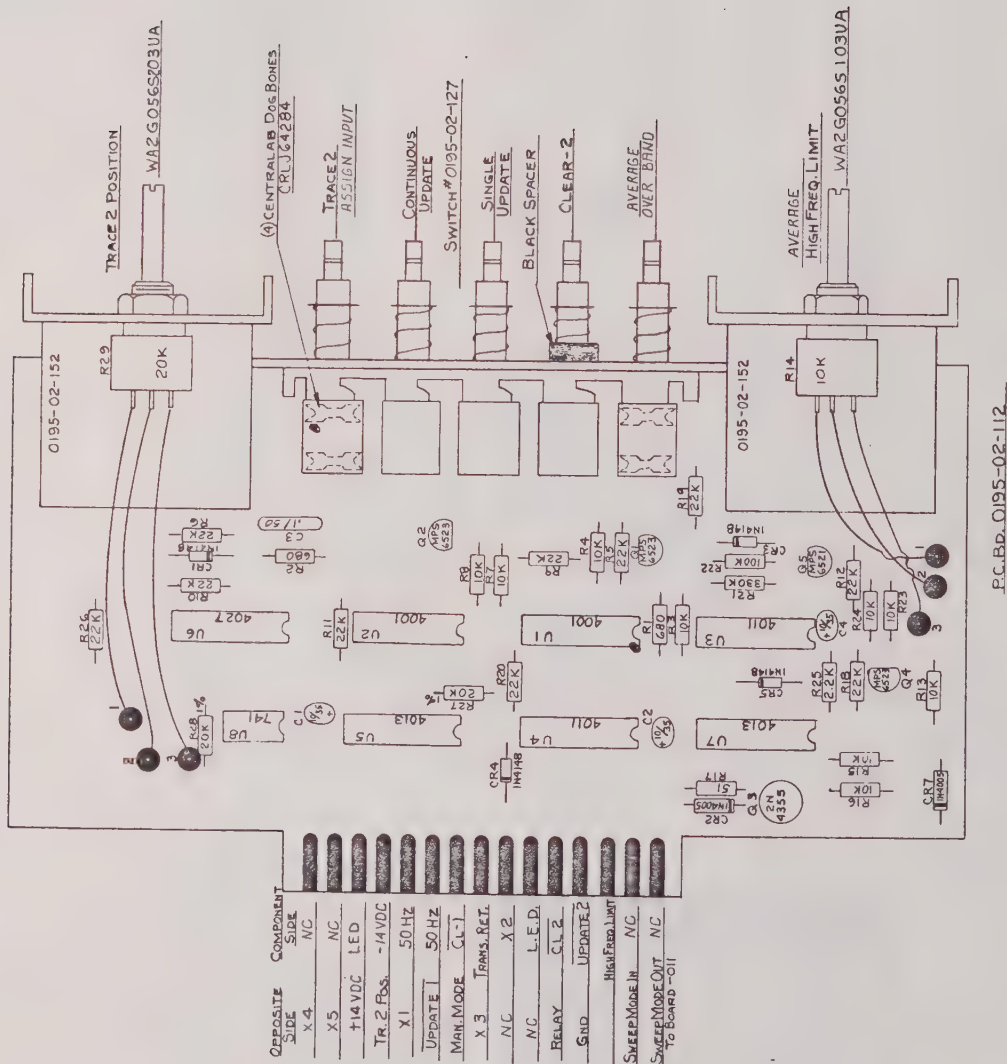
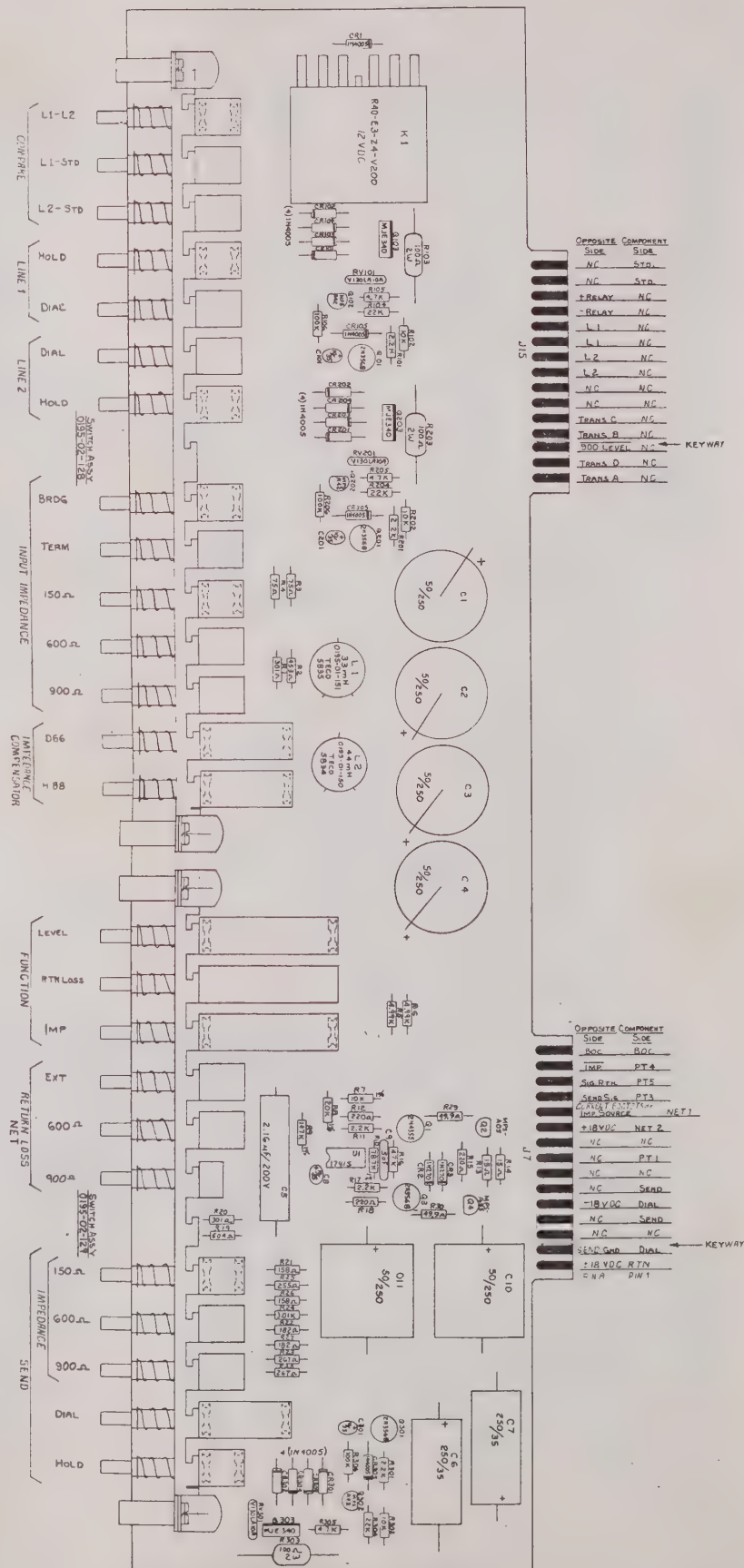


FIGURE 8-5
Control Logic 2 Assembly (012)

FIGURE 8-7
Input and Power Amplifier Assembly (014)



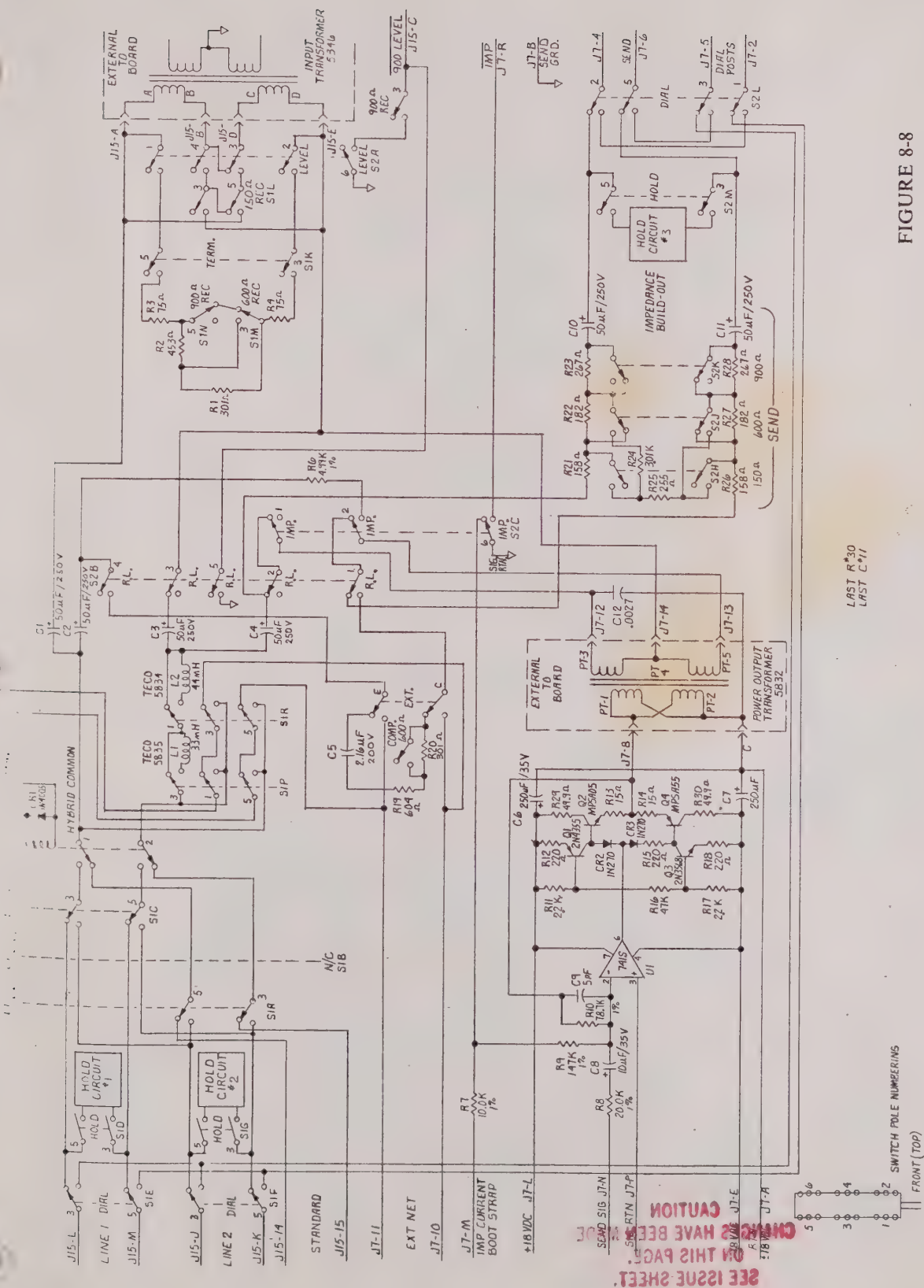
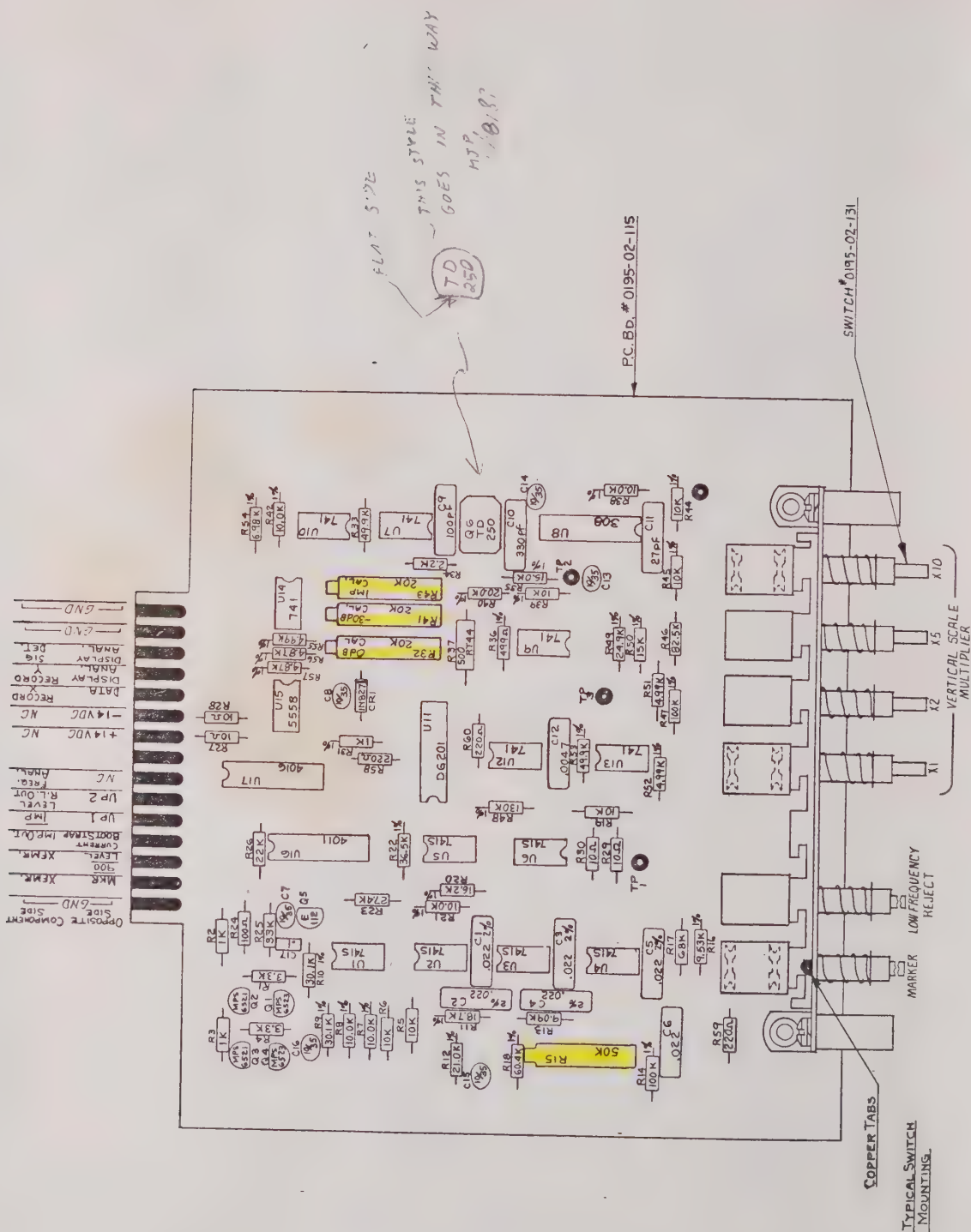


FIGURE 8-8
Input and Power Amplifier Schematic

LAST R*30
LAST C*11

SWITCH POLE NUMBERING
 (TOP)



12/24
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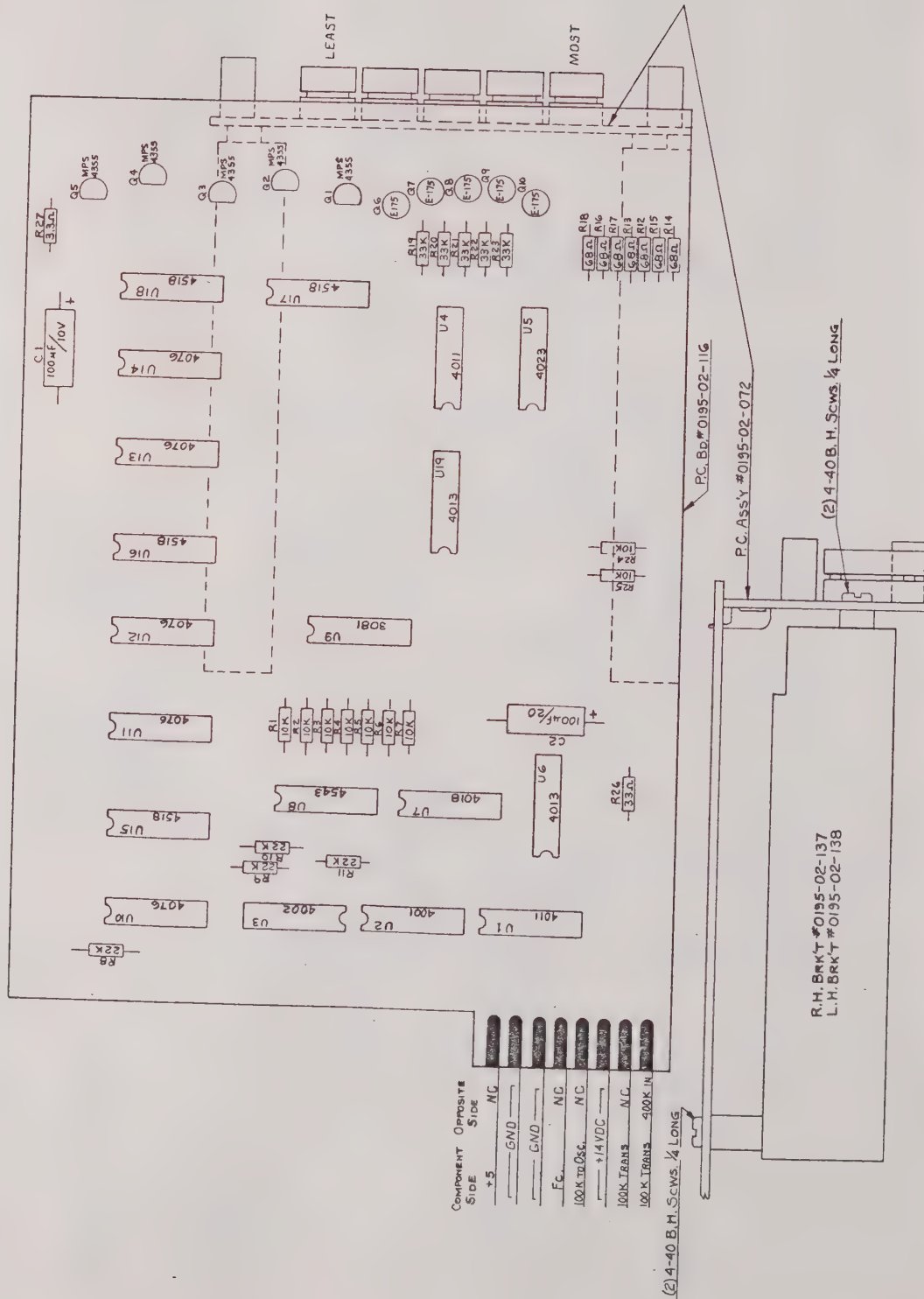


FIGURE 8-11
Frequency Counter and Display Assembly (016)

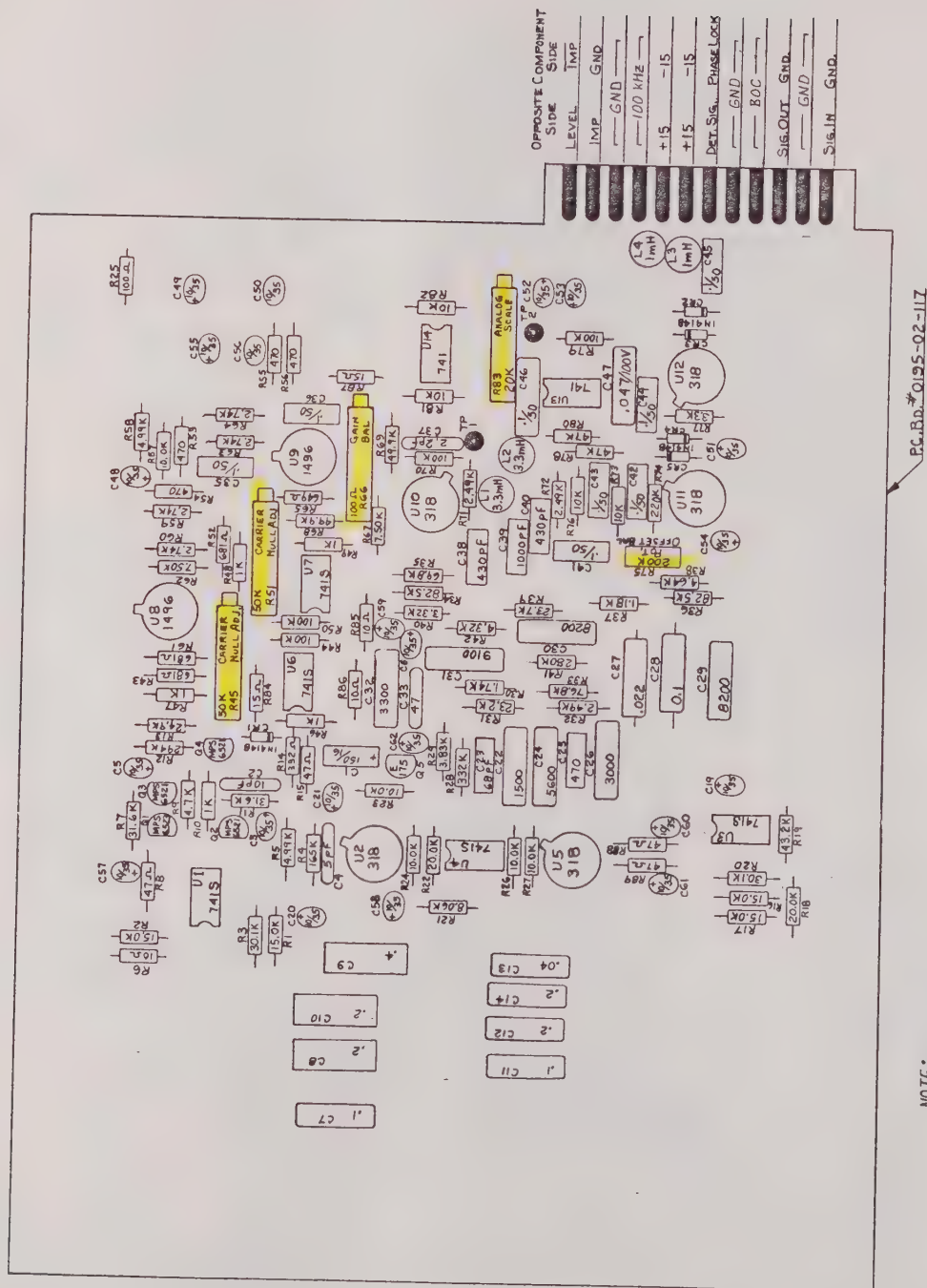
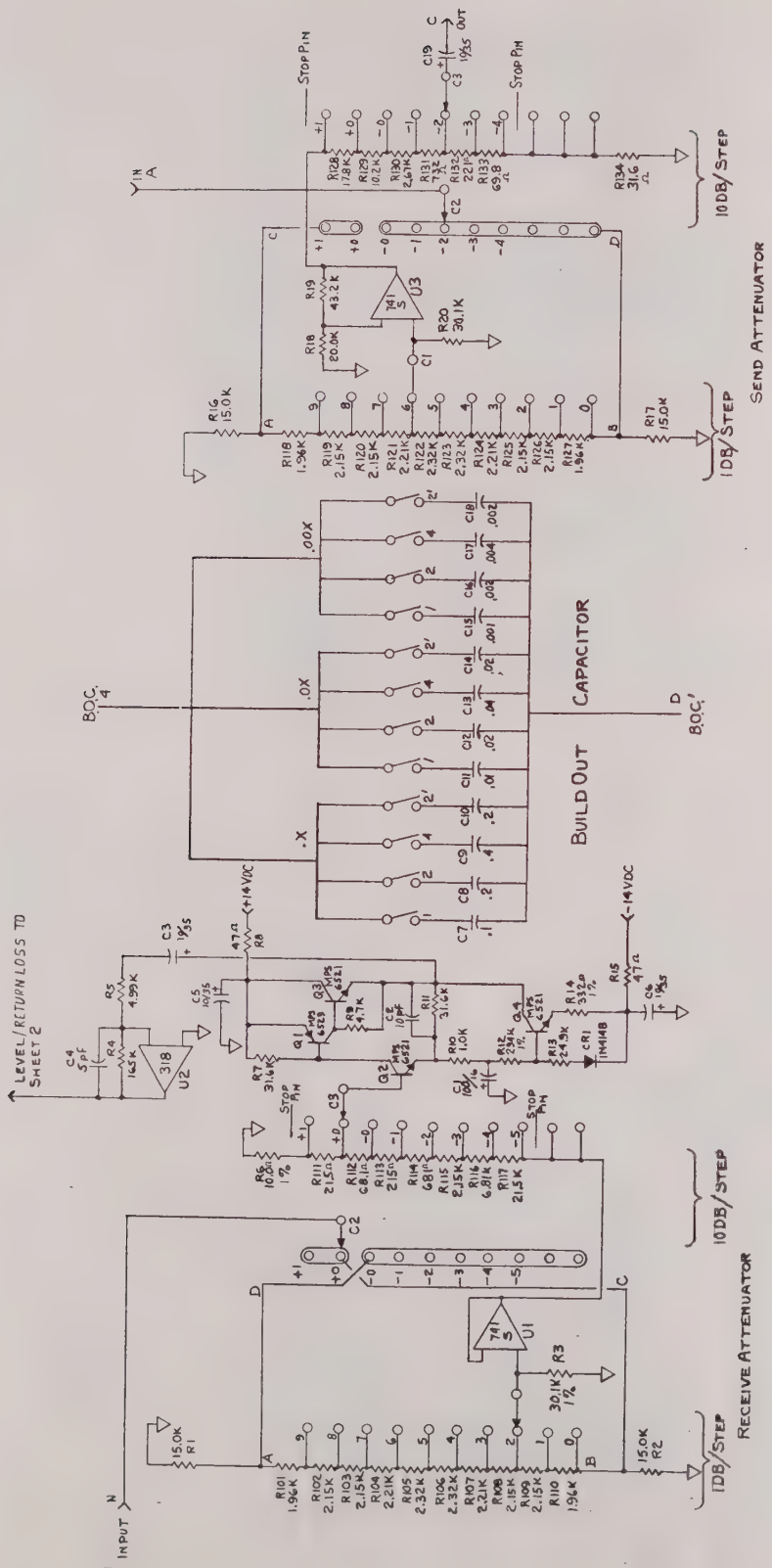


FIGURE 8-13
Measurement Circuit Assembly (017)



- NOTES:
1. RECEIVE AND SEND ATTENUATOR SWITCHES AND RESISTORS, BUILD OUT CAPACITOR SWITCHES AND CAPS ON BO195-02-029.
 2. ALL OTHER COMPONENTS ON CO195-02-D17 P.C. ASSEMBLY.
 3. ALL BUILD OUT CAPACITORS ARE $\pm 1\%$.
 4. RESISTORS ARE ALL 1% UNLESS NOTED.
 5. ALL CAPACITORS IN MF UNLESS NOTED.

LAST REV'D
" C019

FIGURE 8-14a
Measurement Circuit Schematic

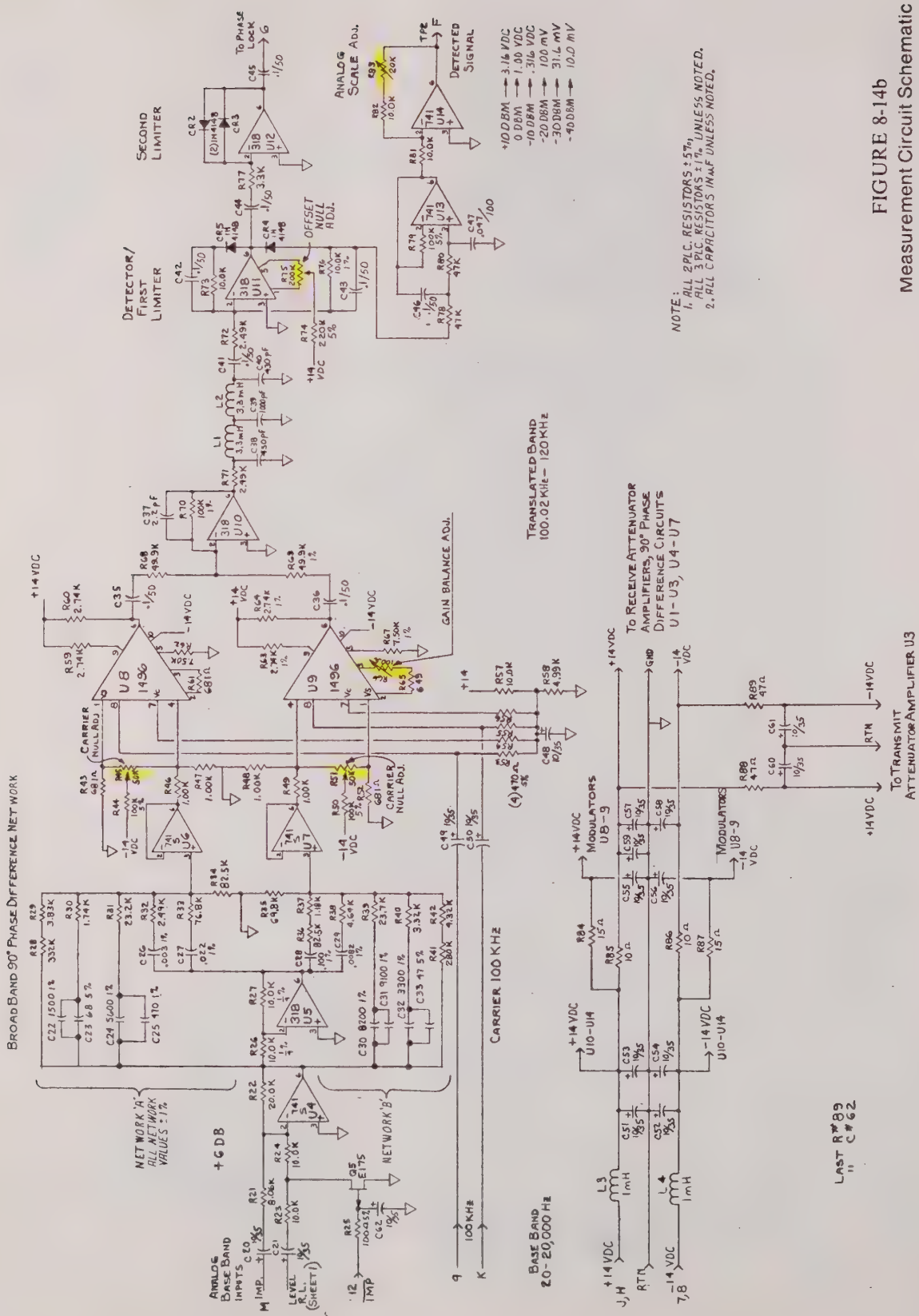


FIGURE 8-14b
Measurement Circuit Schematic

COMPONENT TABULATION

REF	CKT.1	CKT.2	CKT.3
CR-XX1	CR101	CR201	CR301
CR-XX2	CR102	CR202	CR302
CR-XX3	CR103	CR203	CR303
CR-XX4	CR104	CR204	CR304
CR-XX5	CR105	CR205	CR305
C-XX1	C101	C201	C301
R-XX1	R101	R201	R301
R-XX2	R102	R202	R302
R-XX3	R103	R203	R303
R-XX4	R104	R204	R304
R-XX5	R105	R205	R305
R-XX6	R106	R206	R306
Q-XX1	Q101	Q201	Q301
Q-XX2	Q102	Q202	Q302
Q-XX3	Q103	Q203	Q303
RV-XX1	RV101	RV201	RV301

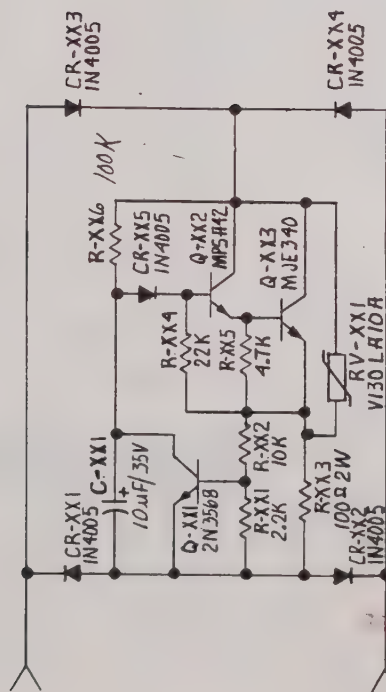
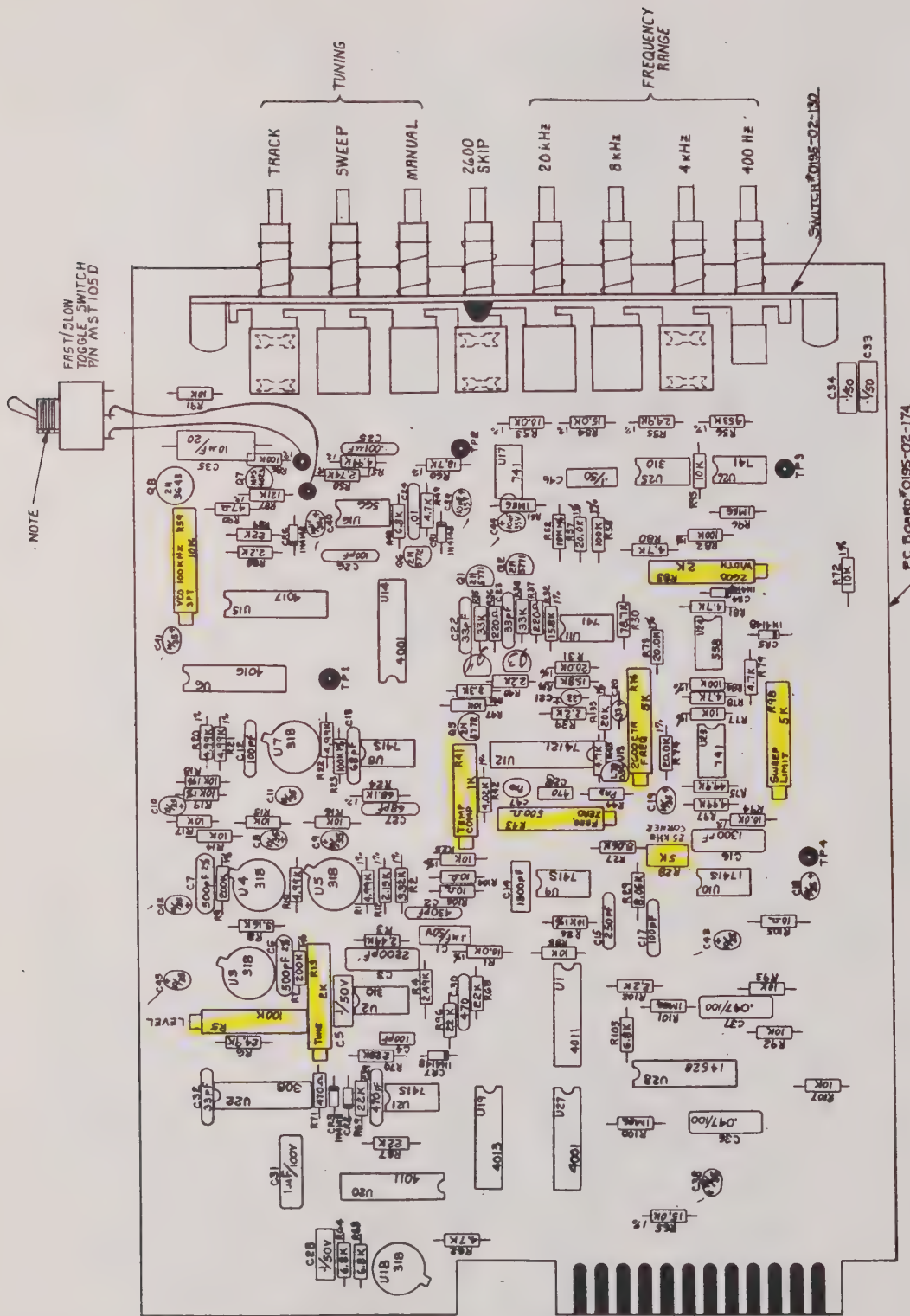


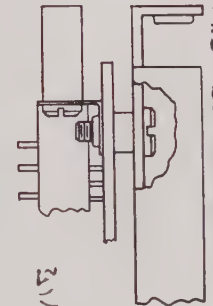
FIGURE 8-15

Hold Circuit



NOTE:
UNLESS OTHERWISE STATED
ALL RESISTORS ±5%
ALL CAPACITORS IN μF

P.C. BOARD #0195-02-174



TYPICAL MOUNTING OF BOTH R.H. AND L.H. SUPPORT BRKTS AND SWITCH

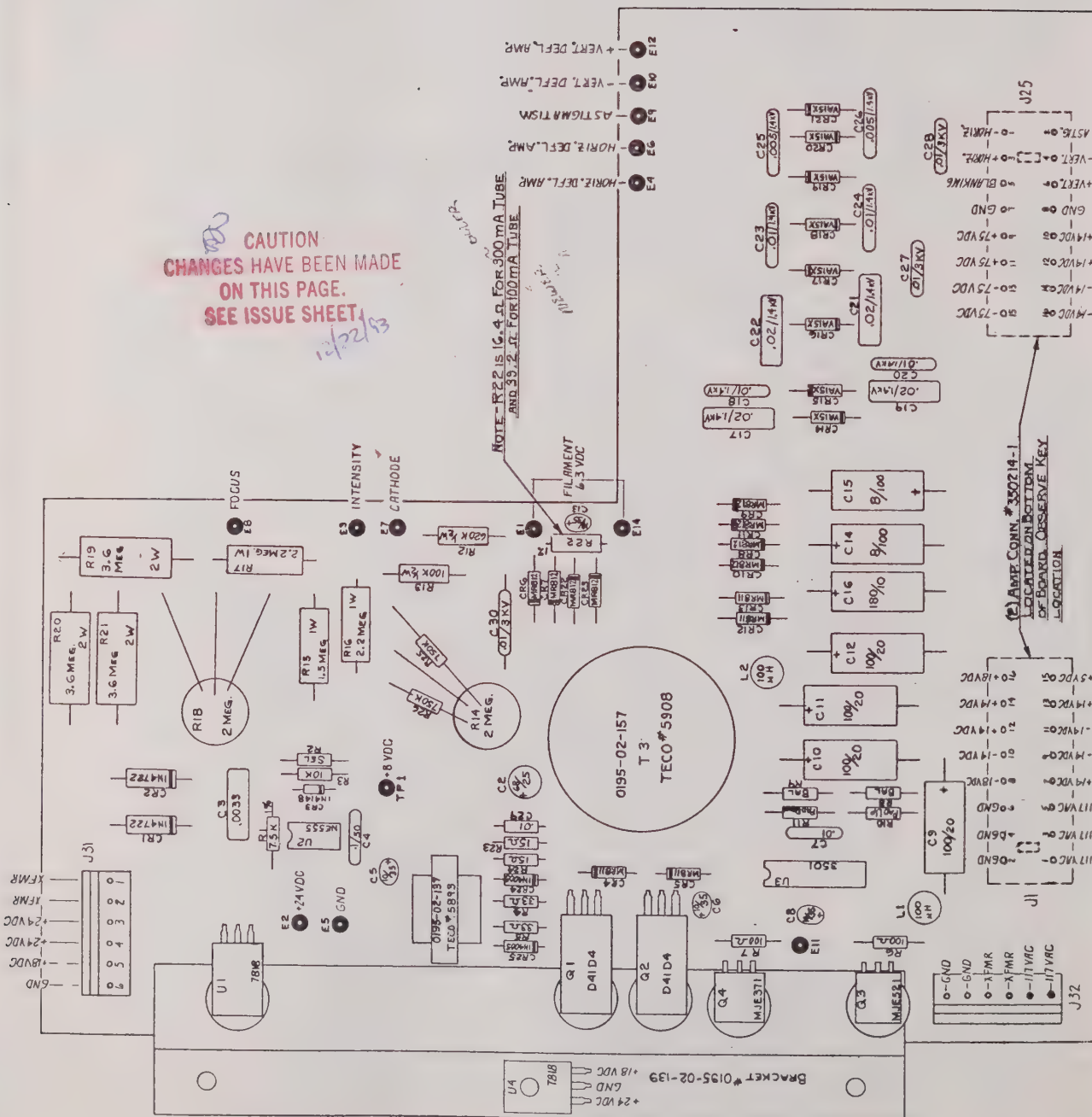
FIGURE 8-16
Sweep Generator Assembly (074)

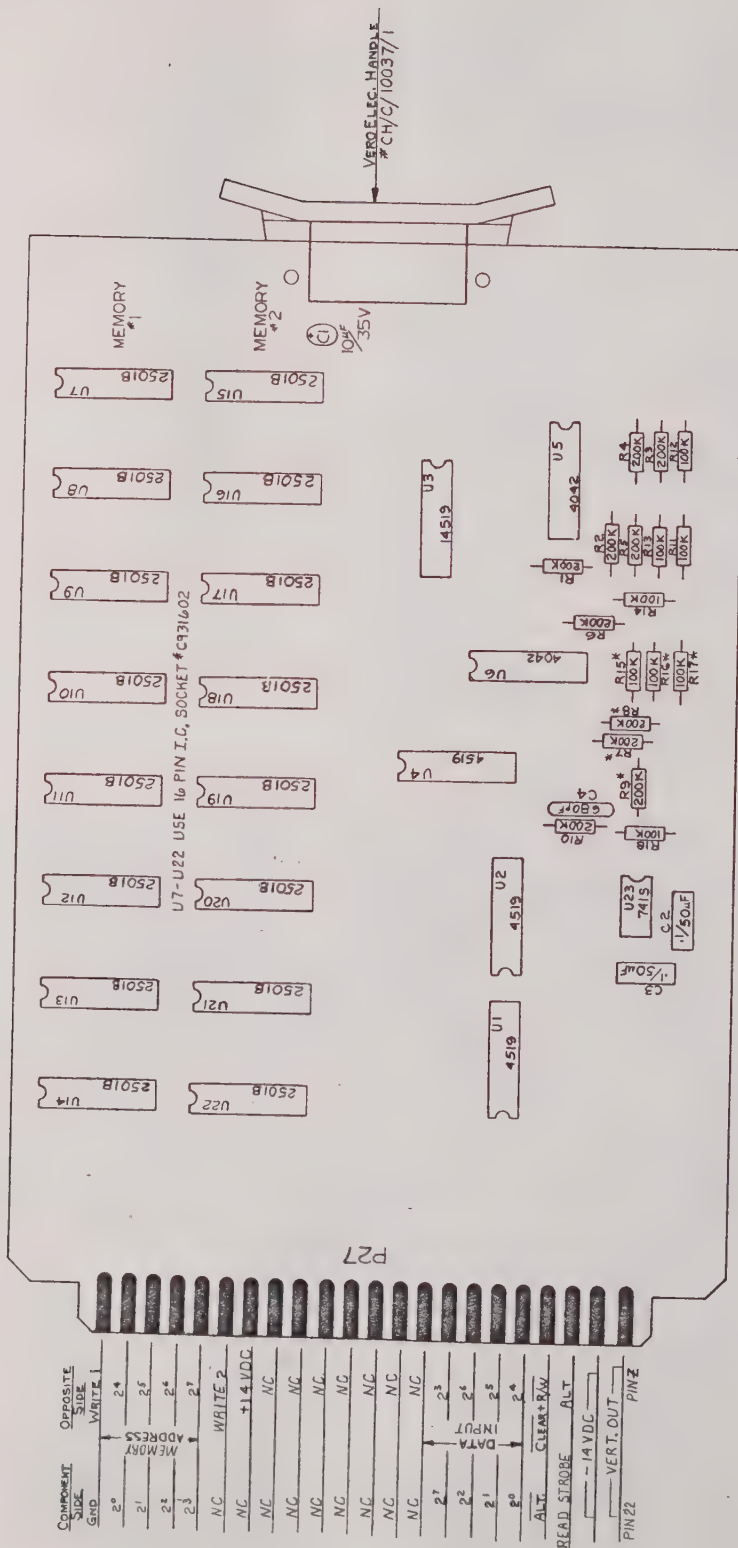
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	COMPONENT	VALUE
A	LOCK	1MHz
B	SWD	NC
C	100kHz	T/R
D	SWD	Man. Pos.
E	SWD	NC
F	SWD	NC
G	SWD	NC
H	SWD	NC
I	SWD	NC
J	SWD	NC
K	SWD	NC
L	SWD	NC
M	SWD	NC
N	SWD	NC

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12/22/83

UNLESS OTHERWISE SPECIFIED
ALL RESISTORS .5%
ALL CAPACITORS IN μ F





***NOTE-**
R7,8,9,15,16,17
ARE ALL 0.25%
ALL OTHER
RESISTORS ARE 1%

FIGURE 8-20
Memory Circuit Assembly (004)

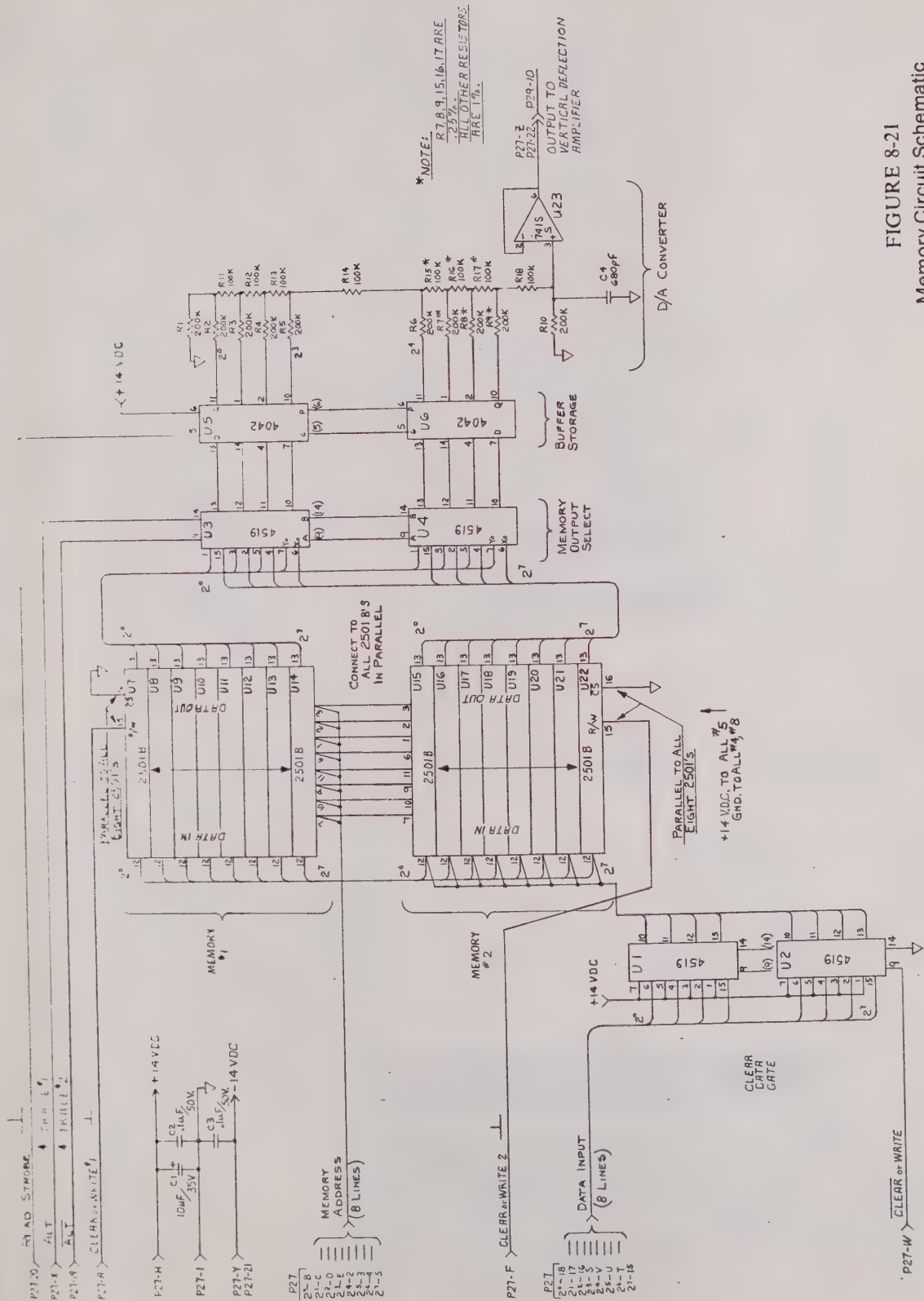
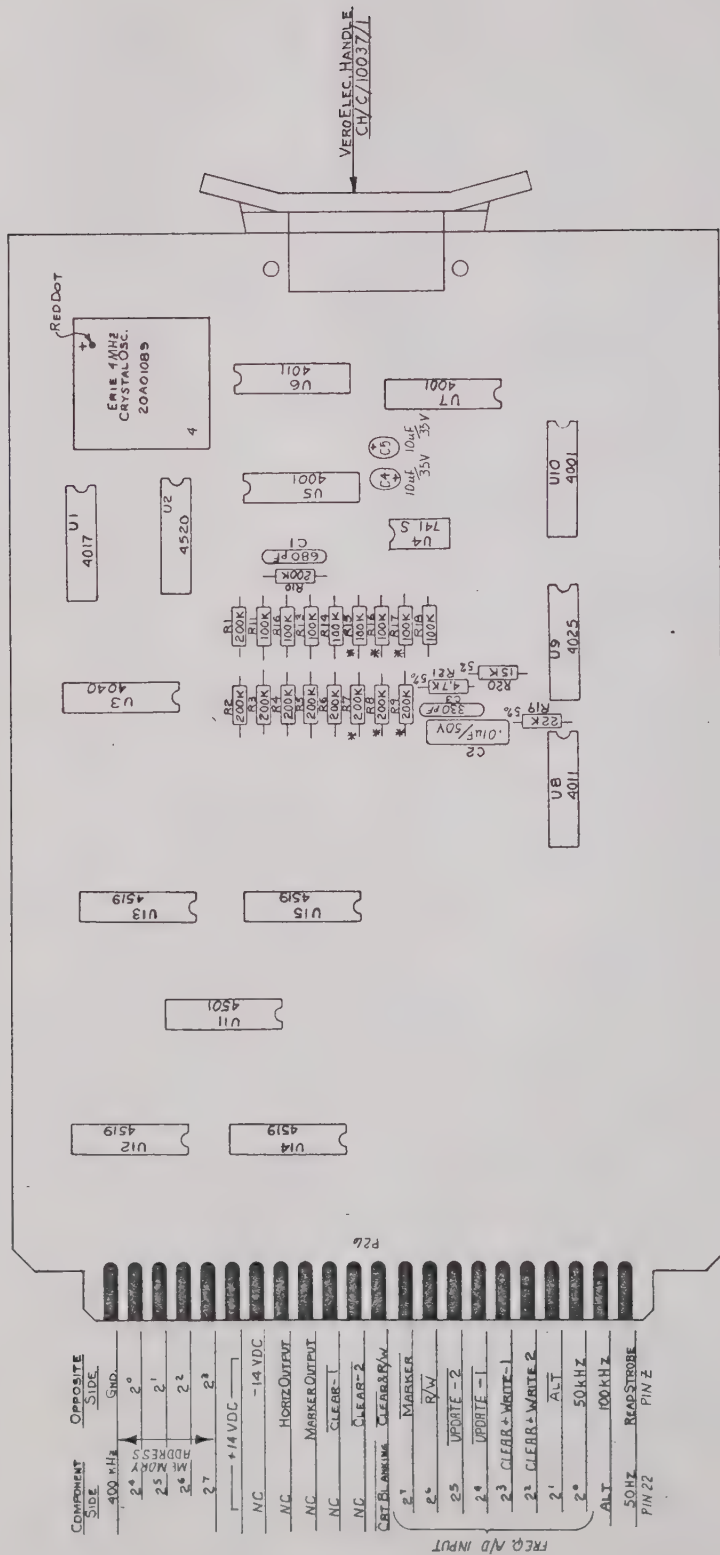


FIGURE 8-21
Memory Circuit Schematic



* NOTE - R1891516.17
 ARE ALL 25%
 ALL OTHER RESISTORS
 ARE 1% UNLESS OTHERWISE
 NOTED

FIGURE 8-22
 Memory Timing Assembly (005)

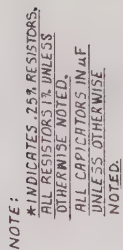
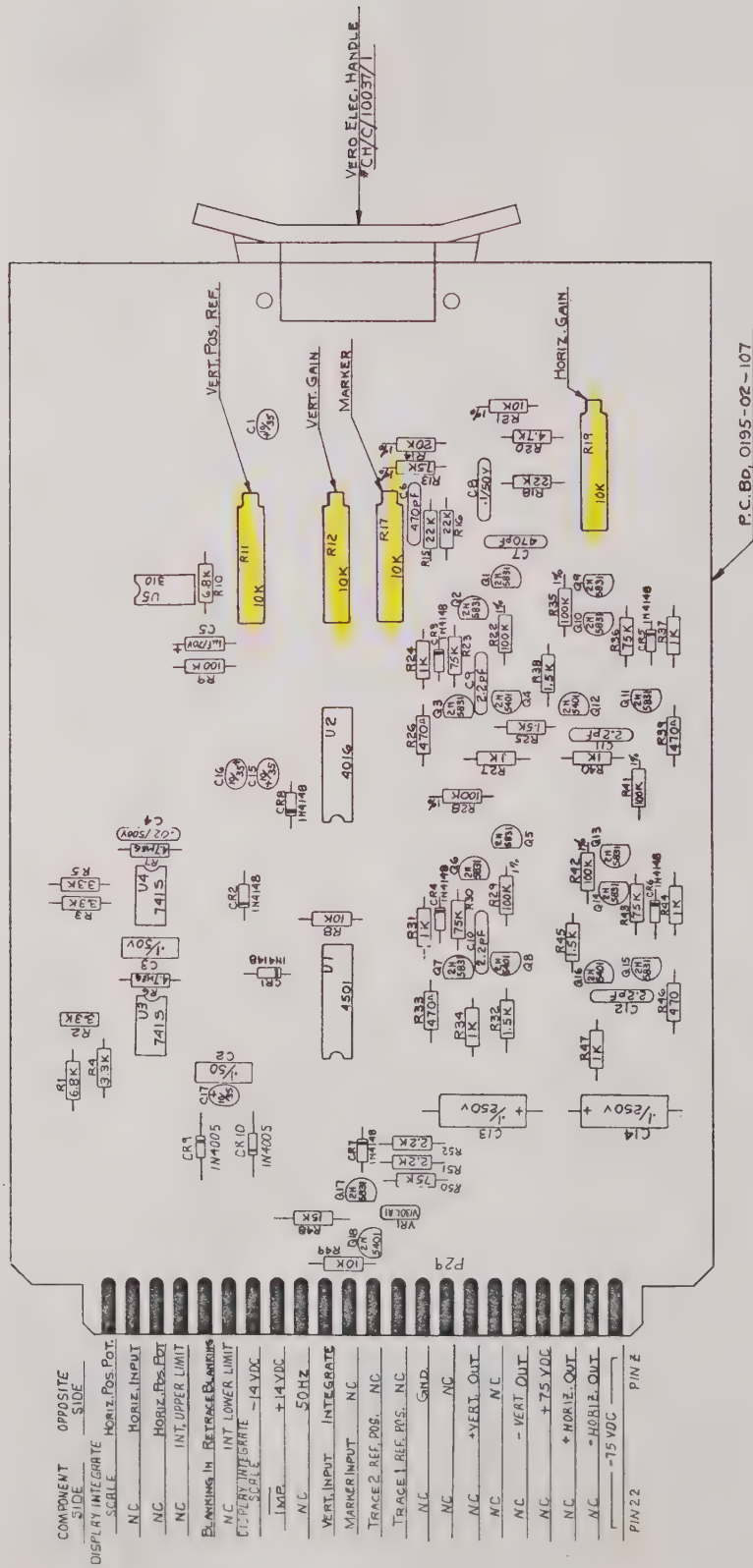


FIGURE 8-24
Analog to Digital Converters Assembly (006)



NOTE:
 ALL RESISTORS 5% UNLESS
 OTHERWISE INDICATED.
 ALL CAPACITORS IN μ F
 UNLESS OTHERWISE INDICATED.

FIGURE 8-26
 Deflection Amplifier Assembly (007)



8-30

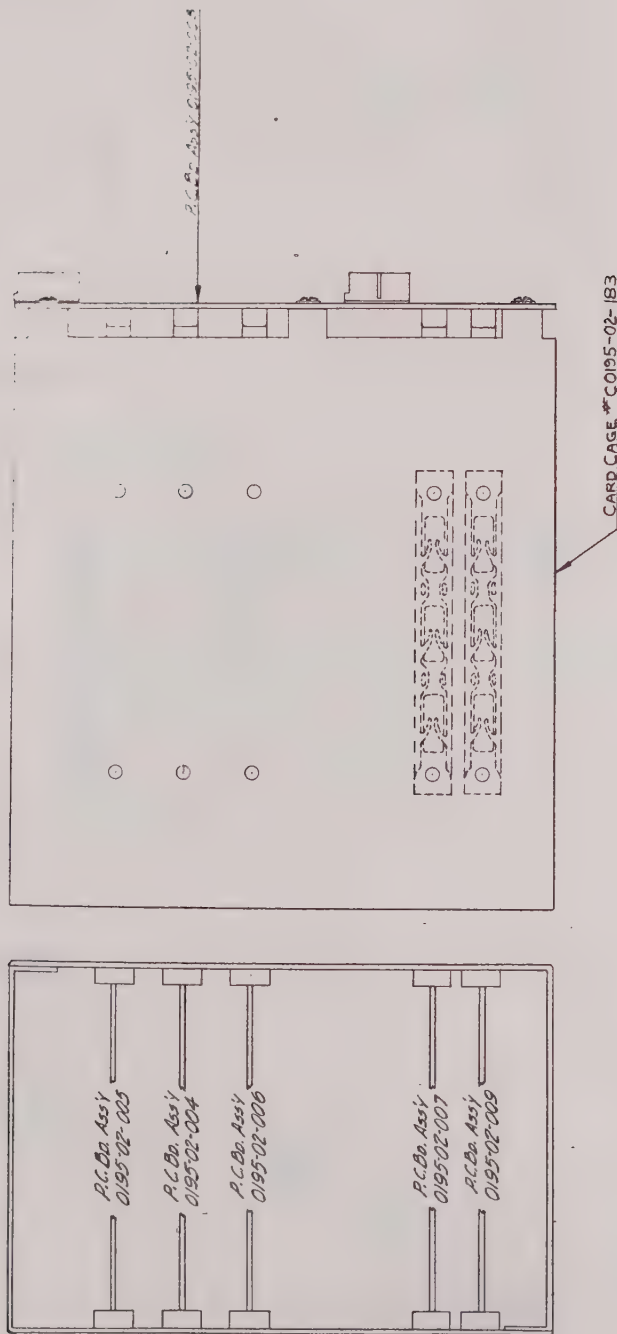


FIGURE 8-29
Card Cage Assembly

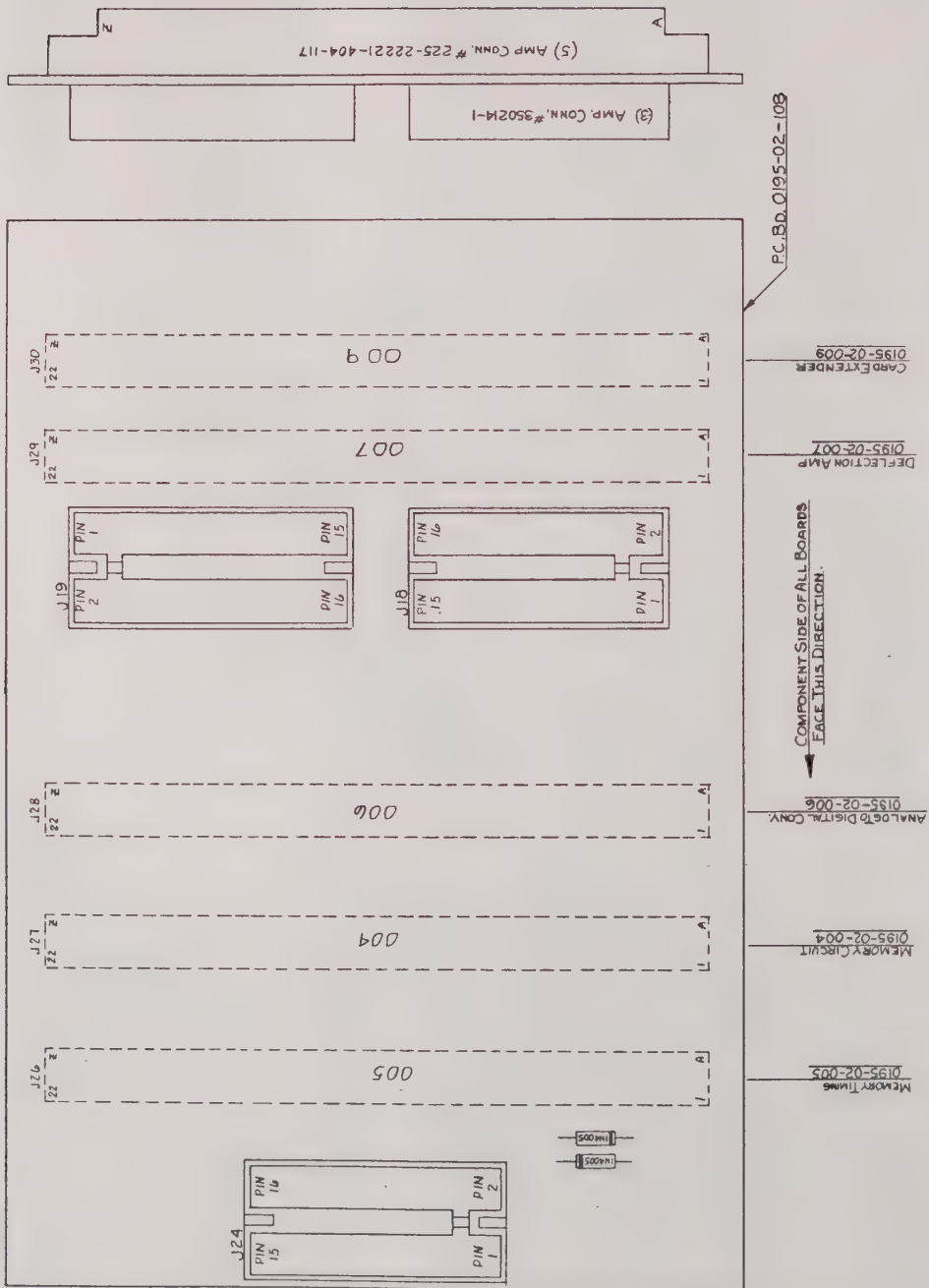


FIGURE 8-30
Mother Board Assembly (008)

9.0 PARTS LIST

9.1 General

9.1.01 The parts list provided on the following pages supplies the description of the various assemblies, sub-assemblies and components that make up the Model T195 Level Tracer.

9.1.02 For those components purchased by Wilcom, the manufacturer and manufacturer's part number are provided. Those components manufactured by Wilcom are identified by a Wilcom part number.

9.1.03 Any required items may be ordered direct from Wilcom Products, Inc. or the manufacturer.

SEE ISSUE SHEET 332
ON THIS PAGE
CHANGES HAVE BEEN MADE
CAUTION

T195 LEVEL TRACER

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	Overall Assembly	1	Wilcom	0195-02-001
	Cover Assembly	1	"	0195-02-297
	Case Assembly	1	"	0195-02-298
	Rear Panel Assembly	1	"	0195-02-020

MAIN ASSEMBLY AND WIRING

Ref. Desig.	Description	Qty	Mfg.	Manufacturer's Number
	Front Panel Assembly	1	Wilcom	0195-02-021
	High Voltage Housing Assembly	1	"	0195-02-075
	Card Cage Assembly	1	"	0195-02-025
	Cathode Ray Tube	1	Phillips	D14-251GH ~~01703814~~
	CR Tube Shield	1	Wilcom	0195-02-032
	Graticule	1	"	0195-02-146
	Bezel	1	"	0195-02-134
	Housing & Panel Support Right	2	"	0195-02-162
	Housing & Panel Support Left	2	"	0195-02-163
	Input Board Support	1	"	0195-02-140
	Harness Assembly	1	"	0195-02-026
	CRT Retaining Block	1	"	0195-02-187
	Input Transformer (Teco #5846)	1	"	0195-02-155
R5	RESISTOR, $\pm 5\%$, 1/4W (assembled on S1)	33k	1	TRW/IRC RG-1/4
	Knob	8	Buckeye	PS50-1
	Knob	1	"	PS95-2
	Shaft Extender	2	H.H. Smith	1441
	Shaft Coupler	2	"	180
	Standoff (Hex)	1	Amatom	8228B-0440
	CRT SOCKET			015015181

COVER ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	Cover	1	Wilcom	0195-02-122

CASE ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	Case Base	1	Wilcom	0195-02-160
	Case Wrap	1	"	0195-02-161

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INFL ASSEMBLY

Description	Qty	Mfr.	Manufacturer's Number
	1	Wilcom	0195-02-179
Timer	1	"	0195-02-133
Unit	1	Belden	17250

INFL

Description	Qty	Mfr.	Manufacturer's Number
Front Panel	1	Wilcom	0195-02-100

LOGIC #1 P.C. ASSEMBLY

Description	Qty	Mfr.	Manufacturer's Number
BOARD	1	Wilcom	0195-02-111
Resistor, $\pm 1\%$, 1/8W	20k	2	TRW/IRC
Resistor, $\pm 5\%$, 1/4W	10k	1	"
Resistor, " "	22k	5	"
Resistor, " "	10k	1	Allen Bradley
Resistor, " "	20k	1	" "
Capacitor, Mono., 50V	.1uF	1	Sprague
Capacitor, Tant., 35V	10uF	2	ITT
Diode, Sm. Sig. Sil.		1	
		1	RCA
		1	741
Assembly (Centralab)	1	Wilcom	0195-02-126
Mounting Bracket	4	Centralab	J52303-04500
Wire Spacers	2	Wilcom	0195-02-152
	4	Centralab	CRLJ64284

LOGIC #2 P.C. ASSEMBLY

Description	Qty	Mfr.	Manufacturer's Number
BOARD	1	Wilcom	0195-02-112
Resistor, $\pm 1\%$, 1/8W	20.0k	2	TRW/IRC
Resistor, $\pm 5\%$, 1/4W	15ohm	1	"
Resistor, " "	680ohm	2	"
Resistor, " "	2.2k	1	"
Resistor, " "	10k	9	"

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
R5,6,9,10,11, 12,18,19, 20,26	Resistor, " "	22k	10	"	"
R22	Resistor, " "	100k	1	"	"
R21	Resistor, " "	330k	1	"	"
R14	Potentiometer	10k	1	Allen Bradley	WAG056S102UA
R29	Potentiometer	20k	1	" "	WA2G056S203UA
CR2,7	Diode, Rectifier, 1A		2		1N4005
CR1,3,4,5	Diode, Sil. Sm. Sig.		4		1N4148
Q1,2,4	Transistor, PNP		3	Motorola	MPS 6523
Q3	Transistor, PNP		1		2N4355
Q5	Transistor, NPN		1	Motorola	MPS 6521
U1,2	IC		2		CD4001AE
U3,4	IC		2		CD4011AE
U5,7	IC		2		CD4013AE
U6	IC		1		CD4027
U8	IC		1		741
S1	Switch Assembly (Centralab)		1	Wilcom	0195-02-127
	Mounting Bracket		2	"	0195-02-152
	Buttons		5	Centralab	J52303-04500

GENERATOR PRINTED CIRCUIT ASSEMBLY

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. BOARD		1	Wilcom	0195-02-174
	Switch, Pushbutton (Centralab)		1	"	0195-02-130
	Support Bracket, Right		1	"	0195-02-135
	Support Bracket, Left		1	"	0195-02-136
	Angle Bracket		2	Federal Screw	36-510
	Standoff		2	Amatom	8276-B-0440
	Dog Bone Spacer		6	Centralab	CRLJ64284
	IC Socket, Low Profile,	14 pin	1	T. I.	C931402
R12	Resistor, $\pm 1\%$, 1/4W	2.15k	1	TRW/IRC	T055
R3,4	Resistor, " "	2.49k	2	"	"
R50	Resistor, " "	2.74k	1	"	"
R8	Resistor, " "	3.16k	1	"	"
R2	Resistor, " "	3.32k	1	"	"
R42	Resistor, " "	4.02k	1	"	"
R10,11,20, 21,22,51,97	Resistor, " "	4.99k	7	"	"
R27,29	Resistor, " "	8.06k	2	"	"
R1,18,19,25 26,52,53,77,94	Resistor, " "	10.0k	9	"	"
R54,65	Resistor, " "	15.0k	2	"	"
R32,34	Resistor, " "	15.8k	2	"	"
R60	Resistor, " "	18.7k	1	"	"
R31,33,57, 73,74	Resistor, " "	20.0k	5	"	"
R6,55	Resistor, " "	24.9k	2	"	"
R75,86	Resistor, " "	49.9k	2	"	"

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	Resistor, " "	33ohm	1	"	"
	Resistor, " "	68ohm	7	"	"
	Resistor, " "	10k	9	"	"
	Resistor, " "	22k	4	"	"
	Resistor, " "	33k	5	"	"
C1	Capacitor, Tant., 10V	100uF	1	Sprague	150D
C2	Capacitor, " 20V	100uF	1	"	"
Q1-5	Transistor, PNP		5	Motorola	MPS 4355
Q6-10	Transistor, FET		5	Siliconix	E-175
U9	IC		1	RCA	CA-3081
U2	IC		1	RCA/Motorola	CD4001AE
U3	IC		1	"	CD4002AE
U1,4	IC		2	"	CD4011AE
U6,9	IC		2	"	CD4013AE
U7	IC		1	"	CD4018AE
U5	IC		1	"	CD4023AE
U15-18	IC		4	Motorola	MC-14518CL
U8	IC		1	"	MC14543CLCP
U10-14	IC		5	N.S./RCA	74C173 or CD4076AE

ATTENUATOR SWITCH AND P.C. BOARD ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	P.C. Board Assembly	1	Wilcom	0195-02-017
	Switch Assembly	1	"	0195-02-029
	Support Bracket, Meas Circ. Bd., Right Hand	1	"	0195-02-147
	Support Bracket, Meas Circ. Bd., Left Hand	1	"	0195-02-148

PRINTED CIRCUIT ASSEMBLY, COUNTER & DISPLAY DAUGHTER BOARD

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	P.C. Board	1	Wilcom	0195-02-172
	Sockets, Display	5	T.I.	C931402
	LED Display	5	H.P.	5082-7730
	Standoff	4	Amatom	9536B-A-0440
	Edge Pin	12	Vector	K28-1A

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
R24	Resistor, " "	68.1k	1	"	"
R30	Resistor, " "	78.7k	1	"	"
R23,58,82, 84	Resistor, " "	100k	4	"	"
R87	Resistor, " "	121k	1	"	"
R7,9	Resistor, " "	200k	2	"	"
R56	Resistor, " "	453k	1	"	"
R44	Resistor, " "	SEL	1	"	"
R104,105, 106	Resistor, $\pm 5\%$, 1/4W	10ohm	3	TRW/IRC	RG-1/4
R90	Resistor, " "	47ohm	1	"	"
R36,37	Resistor, " "	220ohm	2	"	"
R71	Resistor, " "	470ohm	1	"	"
R39,40,88, 102	Resistor, " "	2.2k	4	"	"
R46	Resistor, " "	3.3k	1	"	"
R45,49,62, 78,79,80,81	Resistor, " "	4.7k	7	"	"
R48,63,64, 103	Resistor, " "	6.8k	4	"	"
R14-17,47, 72,85,91,92,93, 95,107	Resistor, " "	10k	12	"	"
R66-69,89, 96	Resistor, " "	22k	6	"	"
R35,38	Resistor, " "	33k	2	"	"
R70	Resistor, " "	220k	1	"	"
R61,99,100 101	Resistor, " "	1Meg	4	"	GBT-1/4
R43	Potentiometer, Cermet	500ohm	1	Bourns	3009P-1-501
R41	Potentiometer, " "	1k	1	"	3009P-1-102
R13,83	Potentiometer, " "	2k	2	"	3009P-1-202
R76,98	Potentiometer, " "	5k	2	"	3009P-1-502
R28	Potentiometer, " "	5k	1	"	3359W-1-502
R59	Potentiometer, " "	10k	1	"	3009P-1-103
R5	Potentiometer, " "	100k	1	"	3009P-1-104
C22,23,32	Capacitor, Disc Cer.	33pF	3	Erie	851-000-COGO-330J
C12	Capacitor, " "	100pF	1	"	841-000-COGO-101J
C29,30	Capacitor, " "	470pF	2	"	831-000-X5F0-471K
C25	Capacitor, " "	.001uF	1	"	801-000-X5F0-102K
C24	Capacitor, " "	.01uF	1	"	811-000-Z5U0-103M
C47	Capacitor, " "N750	SEL	1	"	831/801/851-000-U2J0-xxx
C36,37	Capacitor, Mylar	.047uF	2	Sprague	225P47391WD3
C31	Capacitor, Polycarb.	1.0uF	1	Siemens	B82541-100/5/100
C1,5,28,33, 34,46	Capacitor, Mono., 50V	0.1uF	6	Sprague	7CZ5U104X0050D1
C48	Capacitor, " $\pm 2\%$	470pF	1	Erie	8121-100-COGO-471k
C35	Capacitor, Tant., 20V	10uF	1	Sprague	150D106X9020B2
C8-11,18,19, 38-45	Capacitor, Tant., 35V	10uF	14	ITT	TAG-A10M35
C20,21	Capacitor, " "	.33uF	2	Sprague	196D334X0035HA1
C13,27	Capacitor, Silver Dip	68pF	2	Elmenco	DM15FD680J04CR
C4,17,26	Capacitor, " "	100pF	3	"	DM15FD101J04CR
C15	Capacitor, " "	250pF	1	"	DM15FD251J04CR
C2	Capacitor, " "	430pF	1	"	DM15FD431J04CR

Ref. Desig.	Description		Qty	Mfg.	Manufacturer's Number
C14,16	Capacitor, " "	1300pF	2	"	DM19FD132J04CR
C3	Capacitor, " "	2200pF	1	"	DM19FD222J04CR
C6,7	Capacitor, " "	500pF	2	"	DM15FD501G04CR
CR1-7	Diode, Sil. Sm. Sig.		7	"	1N4148
Q8	Transistor, NPN		1		2N3643
Q3-6	Transistor, NPN		4		2N5772
Q1,2	Transistor, PNP		2		2N5771
Q7	Transistor, PNP		1	Motorola	MPS 6523
U13	IC, 5V regulator		1	Fairchild	78L05AC
U11,17,23, 26	IC, Op amp		4	Motorola	MC1741CP1
U24	IC, " "		1	Raytheon	RC4558DN
U8-10,21	IC, " "		4	Motorola	MC1741SCP
U2,25	IC, " "		2	National	LM310N
U3-5,7,18	IC, " "		5	"	LM310N
U22	IC, " "		1	"	LM308D
U12	IC, Monostable multivibrator		1	T.I.	SN74121N
U14,27	IC, CMOS		2	RCA	CD4001AE
U1,20	IC, " "		2	"	CD4011AE
U19	IC, " "		1	"	CD4013AE
U6	IC, " "		1	"	CD4016AE
U15	IC, " "		1	"	CD4017AE
U28	IC, " "		1	Motorola	MC14528CP
U16	IC, Oscillator		1	Signetics	NE566V

PREAMPLIFIER AND DISPLAY SCALING PRINTED CIRCUIT ASSEMBLY

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. BOARD		1	Wilcom	0195-02-115
R36	Resistor, $\pm 1\%$, 1/8W	499 ohm	1	TRW/IRC	CEATO
R31	Resistor, " "	1.00k	1	"	"
R56,57	Resistor, " "	4.87k	2	"	"
R51,52,55	Resistor, " "	4.99k	3	"	"
R54	Resistor, " "	6.98k	1	"	"
R13	Resistor, " "	9.09k	1	"	"
R16	Resistor, " "	9.53k	1	"	"
R7,8,19,21, 38,39,42,44,45	Resistor, " "	10.0k	9	"	"
R35,50	Resistor, " "	15.0k	2	"	"
R20	Resistor, " "	16.2k	1	"	"
R11	Resistor, " "	18.7k	1	"	"
R40	Resistor, " "	20.0k	1	"	"
R12	Resistor, " "	21.0k	1	"	"
R49	Resistor, " "	24.9k	1	"	"
R23	Resistor, " "	27.4k	1	"	"
R9,10	Resistor, " "	30.1k	2	"	"
R22	Resistor, " "	36.5k	1	"	"
R33,53	Resistor, " "	49.9k	2	"	"
R18	Resistor, " "	60.4k	1	"	"

Ref. Design.	Description	Qty	Mfr.	Manufacturer's Number
R46	Resistor, " "	82.5k	1	" "
R47	Resistor, " "	100k	2	" "
R48	Resistor, " "	130k	1	" "
R27-30	Resistor, $\pm 5\%$, 1/4W	10 ohm	4	" "
R24	Resistor, " "	100 ohm	1	" "
R23	Resistor, " "	1k	2	" "
R34	Resistor, " "	2.2k	1	" "
R41	Resistor, " "	3.3k	2	" "
R46	Resistor, " "	10k	2	" "
R26	Resistor, " "	22k	1	" "
R27	Resistor, " "	33k	1	" "
R28	Resistor, " "	68k	1	" "
R37	Resistor, Temp Comp.	500 ohm	1	T.I. RT44 500
R38-60	Resistor, $\pm 5\%$, 1/4W	220 ohm	3	TRW/IRC RG-1/4
R41,43	Resistor, Variable	20k	3	Bourns 3009P
	Resistor, " "	50k	1	" 3009P
	Capacitor, Mylar	.0047 uF	1	Sprague 225P
	Capacitor, " 100V, $\pm 2\%$	.022 uF	6	F-Dyne PED-2-.022-100-2
	Capacitor, Disc Cer.	27 pF	1	Sprague
	Capacitor, " "	100 pF	1	"
	Capacitor, " "	330 pF	1	"
	Capacitor, Mono.	.1 uF	1	" 7C
	Capacitor, Tant., 35V	10 uF	6	ITT TAG-A10M35
	Transistor, NPN		2	Motorola MPS 6521
	Transistor, PNP		2	" MPs 6523
	Transistor, FET		1	Siliconix E112
	Transistor, Dual, NPN		1	Sprague TD250 (00500215) WL
	Diode, Temp comp zener		1	1N827
	IC		6	Motorola MC1741SCP
	IC		6	741
	IC		1	National LM-308D (00700062) WL
	IC		1	Siliconix DG-201BA
	IC		1	RCA CD4011AE
	IC		1	" CD4016AE
	IC		1	Raytheon RC4558DN
	Switch assembly		1	Wilcom 0195-02-131
	Bracket, Mounting		2	Federal Screw 36-510
	Standoff, square		2	Amatom 8276-B-0440
	Dogbone spacers		6	Centralab CRLJ64284

CAUTION
CHANGES HAVE BEEN MADE
ON THIS PAGE.
SEE ISSUE SHEET. 12/2/83

FREQUENCY COUNTER/DISPLAY PRINTED CIRCUIT ASSEMBLY

Ref Design	Description	Qty	Mfr.	Manufacturer's Number
	P.C. BOARD	1	Wilcom	0195-02-116
	P.C. Daughter Board Subassembly	1	"	0195-02-072
	Daughter Board Support (Right)	1	"	0195-02-137
	Daughter Board Support (Left)	1	"	0195-02-138
	Resistor, $\pm 5\%$, 1/4W	3.3ohm	1	TRW/IRC RG-1/4

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	Resistor, " "	33ohm	1	"	"
	Resistor, " "	68ohm	7	"	"
	Resistor, " "	10k	9	"	"
	Resistor, " "	22k	4	"	"
	Resistor, " "	33k	5	"	"
C1	Capacitor, Tant., 10V	100uF	1	Sprague	150D
C2	Capacitor, " 20V	100uF	1	"	"
Q1-5	Transistor, PNP		5	Motorola	MPS 4355
Q6-10	Transistor, FET		5	Siliconix	E-175
U9	IC		1	RCA	CA-3081
U2	IC		1	RCA/Motorola	CD4001AE
U3	IC		1	"	CD4002AE
U1,4	IC		2	"	CD4011AE
U6,9	IC		2	"	CD4013AE
U7	IC		1	"	CD4018AE
U5	IC		1	"	CD4023AE
U15-18	IC		4	Motorola	MC-14518CL
U8	IC		1	"	MC14543CLCP
U10-14	IC		5	N.S./RCA	74C173 or CD4076AE

ATTENUATOR SWITCH AND P.C. BOARD ASSEMBLY

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. Board Assembly		1	Wilcom	0195-02-017
	Switch Assembly		1	"	0195-02-029
	Support Bracket, Meas Circ. Bd., Right Hand		1	"	0195-02-147
	Support Bracket, Meas Circ. Bd., Left Hand		1	"	0195-02-148

PRINTED CIRCUIT ASSEMBLY, COUNTER & DISPLAY DAUGHTER BOARD

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. Board		1	Wilcom	0195-02-172
	Sockets, Display		5	T.I.	C931402
	LED Display		5	H.P.	5082-7730
	Standoff		4	Amatom	9536B-A-0440
	Edge Pin		12	Vector	K28-1A

PRINTED CIRCUIT ASSEMBLY, MEASUREMENT CIRCUIT

Ref Design.	Description	Qty	Mfr.	Manufacturer's Number
	P.C. Board	1	Wilcom	0195-02-117
R6	Resistor, $\pm 1\%$, 1/4W	1	TRW/IRC	T055
R14	Resistor, " "	1	"	"
R68	Resistor, " "	1	"	"
R43,52,61	Resistor, " "	3	"	"
R10,46-49	Resistor, " "	5	"	"
R17	Resistor, " "	1	"	"
R30	Resistor, " "	1	"	"
R32,71,72	Resistor, " "	3	"	"
R89,60,63,	Resistor, " "	4	"	"
74				
R40	Resistor, " "	1	"	"
R29	Resistor, " "	1	"	"
R42	Resistor, " "	1	"	"
R38	Resistor, " "	1	"	"
R8,88	Resistor, " "	2	"	"
R62,67	Resistor, " "	2	"	"
R21	Resistor, " "	1	"	"
R23,24,57,	Resistor, " "	7	"	"
58,59,62				
R12,16,17	Resistor, " "	4	"	"
R18,22	Resistor, " "	2	"	"
R31	Resistor, " "	1	"	"
R39	Resistor, " "	1	"	"
R13	Resistor, " "	1	"	"
R3,20	Resistor, " "	2	"	"
R7,11	Resistor, " "	2	"	"
R19	Resistor, " "	1	"	"
R68,69	Resistor, " "	2	"	"
7	Resistor, " "	1	"	"
R10	Resistor, " "	1	"	"
R2,4,6	Resistor, " "	2	"	"
1	Resistor, " "	1	"	"
4	Resistor, " "	1	"	"
1	Resistor, " "	1	"	"
1	Resistor, " "	1	"	"
1	Resistor, " "	1	"	"
1	Resistor, " "	1	"	"
1	Resistor, $\pm 5\%$, 1/4W	2	"	"
1	Resistor, " "	2	"	"
1	Resistor, " "	4	"	"
1	Resistor, " "	2	"	RG-1/4
R3,36	Resistor, " "	4	"	"
R77	Resistor, " "	1	"	"
1	Resistor, " "	1	"	"
1	Resistor, " "	2	"	"
1	Resistor, " "	3	"	"
1	Resistor, " "	1	"	"
1	Resistor, $\pm 25\%$, 1/8W	2	"	CEA-T0
1	Potentiometer, $\pm 10\%$	1	Bourns	3009P-1-101
1	Potentiometer, " "	1	"	3009P-1-203
1	Potentiometer, " "	2	"	3009P-1-503
1	Potentiometer, $\pm 20\%$, 1/2W	1	"	3359W-1-204
1	Capacitor, Tant., 35V	21	ITT	TAG-A10M35

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
48-62					
C1	Capacitor, Elect., 16V	100 uF	1	Siemens	B41316
C35,36, 41-46	Capacitor, Mono., 50V	.1 uF	8	Sprague	7CZ5U104X0050D1
C37	Capacitor, Ceramic, 1000V	2.2 pF	1	Erie	CK60BX2R2K
C4	Capacitor, " "	5 pF	1	"	10TCCV50
C2	Capacitor, " 500V	10 pF	1	"	831-000-COGO-100D
C47	Capacitor, Mylar, 100V	.047 uF	1	"	225P47391WD3
C27	Capacitor, Polysulfone	.022 uF	1	F-Dyne	PF-11-.022-50-1
C28	Capacitor, "	.1 uF	1	"	PF-11-.100-50-1
C11	Capacitor, Met. Polycarb.	.01 uF	1	"	MPC-11-.010-150-1
C12,14	Capacitor, " "	.02 uF	2	"	MPC-11-.020-150-1
C13	Capacitor, " "	.04 uF	1	"	MPC-11-.040-150-1
C7	Capacitor, " "	.1 uF	1	"	MPC-11-.100-150-1
C8,10	Capacitor, " "	.2 uF	2	"	MPC-11-.200-150-1
C9	Capacitor, " "	.4 uF	1	"	MPC-11-.400-150-1
C33	Capacitor, Sil. Mica	47 pF	1	Elmenco	DM15ED470J04CR
C23	Capacitor, " "	68 pF	1	"	DM15ED680J04CR
C38,40	Capacitor, " "	430 pF	2	"	DM19FD431G04CR
C39	Capacitor, " "	1000 pF	1	"	DM19FD102G04CR
C25	Capacitor, " "	470 pF	1	"	DM19FD471F04CR
C22	Capacitor, " "	1500 pF	1	"	DM19FD152F04CR
C26	Capacitor, " "	3000 pF	1	"	DM19FD302F04CR
C32	Capacitor, " "	3300 pF	1	"	DM19FD332F04CR
C24	Capacitor, " "	5600 pF	1	"	DM30FD562F04CR
C29,30	Capacitor, " "	8200 pF	2	"	DM30FD822F04CR
C31	Capacitor, " "	9100 pF	1	"	DM30FD912F04CR
L3,4	Inductor	1 mH	2	Cambion	553-3635-37
L1,2	Inductor	3.3 mH	2	"	553-3635-43
CR1-5	Diode		5		1N4148
Q2,3,4	Transistor, NPN		3	Motorola	MPS6521
Q1	Transistor, PNP		1	"	MPS6523
Q5	Transistor, P-Chan, FET		1	Siliconix	E-175
U1,3,4,6,7	IC		5	Motorola	MC1741SCP
U2,5,10-12	IC		5	Nat'l Semi.	LM318N
U8,9	IC		2	Silicon Gen.	SG1496
U13,14	IC		2	Silicon Gen.	741

INPUT AND POWER AMPLIFIER P.C. BOARD ASSEMBLY

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. BOARD		1	Wilcom	0195-02-114
	Standoff, square		4	Amatom	8276-B-0440
R3,4	Resistor, $\pm 1\%$, 1/4W	75 ohm	2	TRW/IRC	T055
R21,26	Resistor, " "	158 ohm	2	"	"
R22,27	Resistor, " "	182 ohm	2	"	"
R25	Resistor, " "	255 ohm	1	"	"
R23,28	Resistor, " "	267 ohm	2	"	"
R1,20	Resistor, " "	301 ohm	2	"	"
R2	Resistor, " "	453 ohm	1	"	"

Part Design	Description		Qty	Mfr.	Manufacturer's Number
	Resistor, " "	604 ohm	1	"	"
	Resistor, " "	4.99k	2	"	"
	Resistor, " "	3.01k	1	"	"
	Resistor, " "	10.0k	1	"	"
	Resistor, " "	20.0k	1	"	"
	Resistor, " "	78.7k	1	"	"
	Resistor, " "	147k	1	"	"
	Resistor, $\pm 5\%$, 1/4W	220 ohm	3	"	RG-1/4
101	Resistor, " "	2.2k	5	"	"
	Resistor, " "	4.7k	3	"	"
202	Resistor, " "	10k	3	"	"
204	Resistor, " "	22k	3	"	"
	Resistor, " "	47k	1	"	"
	Resistor, " "	100k	3	"	"
3	Resistor, 2W	100 ohm	3		
	Resistor, $\pm 1\%$, 1/2W	15 ohm	2	TRW/IRC	T060
	Resistor, " "	49.9 ohm	2	"	"
	Capacitor, Foil, $\pm 5\%$	2.16 uF	1		
	Capacitor, Tant., 40V	220 uF	2	Semien	
	Capacitor, " 250V	50 uF	6	Sprague	39D
	Capacitor, " 35V	10 uF	4	ITT	TAG-A10M35
	Capacitor, Ceramic	5 pF	1	Sprague	
	Capacitor, Mylar	.0027 uF	1	"	225P27291WD3
10	Varistor		3	G.E.	V130LA10A
2	Diode, Rectifier, 1A		16		1N4005
105	Transistor, NPN		1	Motorola	MPSA05
	Transistor		1		2N4355
	Transistor		4		2N3568
	Transistor		3	Motorola	MPS A42
	Transistor		3	"	MJE 340
	Transistor, PNP		1	"	MPS A55
	Diode		2		1N270
	Choke (Teco 5835)		1	Wilcom	0195-02-151
	Choke (Teco 5834)		1	"	0195-02-150
	IC		1	Motorola	MC1741SCP
	Relay		1	P & B	R40E3Z4V200
	Input Switch Assembly		1	Wilcom	0195-02-128
	Power Amp Switch Assembly		1	"	0195-02-129
	Bracket		4	Federal Screw	36-510

CARD CAGE ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	Card Cage	1	Wilcom	0195-02-183
	Mother Board Assembly	1	"	0195-02-008
	Memory Circuit Assembly	1	"	0195-02-004
	Memory Timing Assembly	1	"	0195-02-005
	A/D Converter Assembly	1	"	0195-02-006
	Deflection Amplifier Assembly	1	"	0195-02-007
	Card Extender Assembly	1	"	0195-02-009
	Card Guides	10	Unitrack	RAD4125

SHIELD ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	Shield	1	Wilcom	0195-02-123

WIRING HARNESS ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	Connector, 15 pin	5	Amp	1-582147-5
	" 12 pin	2	Amp	583950-1
	" 8 pin	1	"	582140-5
	" 16 pin	5	"	1-480438-0
	Crimp Pins	146	"	42840-4
				583989-4
	Blank Pins	68	Amp	66084-1
	Pins	68	"	60617-1
	Intercontact Key	6	"	582501-1
	Connector, 3 pin	2	Molex	03-06-1031
	Pins	5	"	02-06-1103

MOTHER BOARD ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
CR 1,2	P.C. BOARD	1	Wilcom	0195-02-108
	DIODE, Rectifier, 1A	2		1N4005
	Card Edge Connector, 22 pin	5	Amphenol	225-22221-410-117
	Connector, 16 pin	3	Amp	350214-1

MEMORY TIMING ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	P.C. BOARD	1	Wilcom	0195-02-105
	Handle	1	Vero Elect.	CH/C/10037/1
	Oscillator, 4 mc Crystal	1	Erie	20A01089-3
U12,13,14, 15	IC	4	Motorola	MC14519CP/CL
U11	"	1	"	MC14501CP/CL
U5,7,10	"	3	RCA	CD4001BE
U6,8	"	2	"	CD4011BE
U1	"	1	"	CD4017AE
U9	"	1	"	CD4025BE
U3	"	1	"	CD4040AE
U2	"	1	Motorola	MC14520CP/CL
U4	"	1	Mot-Silgen	MC1741SCP
R11-14,18	RESISTOR, $\pm 1\%$, 1/4W	5	TRW/IRC	T055
R1-6,10	" " " "	7	"	"
R15,16,17	" $\pm 0.25\%$, 1/8W	3	"	CEATO
R7,8,9	" " "	3	"	"
R21	" $\pm 5\%$, 1/4W	1	"	RG-1/4
R20	" " "	1	"	"
R19	" " "	1	"	"
C3	CAPACITOR, Ceramic, $\pm 10\%$, 500V	1	Erie	831-000-X5F0-331K
C1	" " " " "	1	"	801-000-X5F0-681K
C2	" Monolythic, $\pm 20\%$, 50V	1	Sprague	7CZ50104X0050D1
C4,5	" Tant., $\pm 20\%$, 35V	2	ITT	TAG-A10M35

MEMORY P.C. ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	P.C. BOARD	1	Wilcom	0195-02-104
	Handle	1	Vero Elect.	CH/C/10037/1
U7-22	IC	16	Signetics	2501B
U1-4	IC	4	Motorola	MC14519CP/CL
U5,6	"	2	RCA	CD4042AE
U23	"	1	Mot-Silgen	MC1741SCP
	IC Sockets, 16 pin	16	T.I.	C931602
R11-14,18	RESISTOR, $\pm 1\%$, 1/8W	5	IRC/TRW	CEATO
R1-6,10	" " " "	7	"	"
R15,16,17	" $\pm 0.25\%$, "	3	"	"
R7,8,9	" " "	3	"	"
C4	CAPACITOR, Ceramic, $\pm 10\%$, 500V	1	Erie	801-000-X5F0-681K
C2,3	" Monolythic, $\pm 20\%$, 50V	2	Sprague	7CZ5010RX0050D1
C1	" Tant., $\pm 20\%$, 35V	1	ITT	TAG-A10M35

TRACKING A/D CONVERTERS P.C. BOARD ASSEMBLY

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. BOARD		1	Wilcom	0195-02-106
	Handle		1	Vero Elect.	CH/C/10037/1
U7-10	IC		4	Motorola	MC14516CP
U5	IC		1	RCA	CD4001AE
U1-4	IC		4	"	CD4011AE
U20	IC		1	T.I.	SN72741P
U6	IC		1	RCA	CD4013AE
U16-19	IC		4	National	LM 318H
U11-15	IC		5	Motorola	MC1741SCP
R46,48,57, 59	RESISTOR, $\pm 1\%$, 1/8W	374 ohm	4	TRW/IRC	CEATO
R65	" " "	1.54k	1	"	"
R37-40,51, 52	" " "	20.0k	6	"	"
R42,53	" " "	49.9k	2	"	"
R11-14,18, 29-32,36, 45,47,56,58,63	" " "	100k	15	"	"
R1-6,10, 19-24,28	" " "	200k	14	"	"
R15-17,33, 34,35	RESISTOR, $\pm 0.25\%$, 1/8W	100k	6	"	"
R7-9,25-27	" " "	200k	6	"	"
C8	CAPACITOR, Ceramic Disc,	15 pF	1	Erie	831-000-U2J0-150J
C6,7	" " "	75 pF	2	"	
C1,2	" Monolythic, 50V	0.1 uF	2	Sprague	7C
C3,4,5	" Tant., $\pm 20\%$, 30V	10 uF	3	ITT	TAG-A10M35
CR1-5	DIODE, Sm. Sig. Sil.		5		1N4148
R41	POTENTIOMETER, Cermet	20k	1	Bourns	3009P-20K
R67	RESISTOR, $\pm 5\%$,	2200 pF	1	IRC	CG-1/4
R43,44,54, 55,62	" "	4700 pF	5	"	"
R49,50,60, 61,66	" "	10k	5	"	"
R64	" "	1 MEG	1	"	"

DEFLECTION AMPLIFIERS P.C. BOARD ASSEMBLY

Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. BOARD		1	Wilcom	0195-02-107
	Handle		1	Vero Elect.	CH/C/10037/1
R13	RESISTOR, $\pm 1\%$, 1/8W	7.5k	1	TRW/IRC	CEATO
R21	" " "	10.0k	1	"	"
R14	" " "	20.0k	1	"	"
R22,28,29 35,41,42	" " "	100k	6	"	"
R26,33,39,	Resistor, $\pm 5\%$, 1/4W	470 ohm	4	"	RG-1/4

Ref Desig.	Description	Qty	Mfr.	Manufacturer's Number
46 R24,27,31, 34,37,40,44,47	" " "	1k	8	" "
R25,32,38, 41	" " "	1.5k	4	" "
R51,52	" " "	2.2k	2	" "
R21,34,5	" " "	3.3k	4	" "
R20	" " "	4.7k	1 "	" "
R3,10	" " "	6.8k	2	" "
R4,11	" " "	10k	2	" "
R6	" " "	15k	1	" "
R7,8,9,18	" " "	22k	3	" "
R1,10,30, 33,35	" " "	75k	5	" "
R2,3	" " "	100k	1	" "
R22	" " "	4.7 MEG	2	" "
R23,7	Resistor, Variable	10k	4 Bourns	3009P-10k
C1,2	Capacitor, Ceramic	2.2 pF	4 Sprague	
C3	Capacitor, "	470 pF	2 "	
C4	Capacitor, "	.02 uF	1 Erie	25u
C5	Capacitor, Mono., 50V	.1 uF	3 Sprague	7C
C6,7,14	Capacitor, Foil, 250V	.1 uF	2 Indico	
C8	Capacitor, Tant., 20V	1 uF	1 Sprague	150D
C9,13,17	Capacitor, " 35V	10 uF	4 ITT	TAG-A10M35
CR1,5	Diode, Sm. Sig. Sil.		8	1N4148
Q1,2,15,6	Transistor, NPN		13 Fairchild	2N5831
Q3,10,11, 12,14,15,17				
Q4,8,12,16,	Transistor, PNP	5	Motorola	2N5401
U3,4	IC	2	Motorola	MC-1741S-CP
U5	IC	1	National	LM310N
U7	IC	1	Motorola	MC-14501CP
U2	IC	1	RCA	CD4016AE
CR9,10	Diode, Rectifier, 1A	2		1N4005
VR1	Varistor	1	G.E.	V130LA1

CARD EXTENDER P.C. BOARD ASSEMBLY

Ref Desig.	Description	Qty.	Mfr.	Manufacturer's Number
	P.C. BOARD	1	Wilcom	0195-02-109
	P.C. Connector, 22 pin	1	Cinch	50-44-S-30

FRONT PANEL ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	Front Panel	1	Wilcom	0195-02-002
A6 (J20)	P.C. Assembly, Control Logic #1	1	"	0195-02-011
A7 (J21)	P.C. Assembly, Control Logic #2	1	"	0195-02-012
A8 (J15)	P.C. Assembly, Input Circuits	1	"	0195-02-014
A9 (J12)	P.C. Assembly, Preamp. & Display Scaling	1	"	0195-02-015
A10 (J5)	P.C. Assembly, Counter & Display	1	"	0195-02-016
A12 (J2)	P.C. Assembly, Attenuator Switch	1	"	0195-02-030
A13 (J4)	P.C. Assembly, Generator	1	"	0195-02-074
	Dial Post	2	"	0132-10-132
	Panel Window	1	"	0179-00-122
	Binding Post (Red)	6	Grayhill	29-1R
	Binding Post (Black)	8	"	29-1B
	Receptacle	1	TRW/Cinch	250-06-30-170
S3,4,5	Switch	3	Alco	MST105D
	Handle w/ #10 screws supplied	2	Bud	H-9111
R1	POTENTIOMETER, $\pm 10\%$, 1W	1k 1	Bourns	3059J-1-102
R2	POTENTIOMETER, 10 turn, $\pm 10\%$, 2W	10k 1	"	3501S-1-103
R3	POTENTIOMETER, $\pm 10\%$, 1/2W	10k 1	Wilcom	0195-02-188
R4	POTENTIOMETER, $\pm 10\%$, 1/2W	500k 1	"	0195-02-189
	Panel Bearings	2	H.H. Smith	184
DS1,2	Led and Panel Bushing	2	Datalight	LE2 #2
S1	Switch	1	Marco Oak	616-6-1
	Lamp	1	C.M.L.	A1H

HIGH VOLTAGE HOUSING ASSEMBLY

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	P.C. Assembly, Power Supply	1	Wilcom	0195-02-086
	Housing	1	"	0195-02-073
R29,30	RESISTOR, $\pm 1\%$, 3/4W	475 ohm 2	TRW/IRC	T060
R28	POTENTIOMETER	2.5k 1	Bourns	3852A-162-252A
C1	CAPACITOR, Elect., 30V	8000 uF 1	G.E.	86F547M
T1	TRANSFORMER, Power	1	Wilcom	0195-02-184
T4	" Teco #5832	1	"	0195-02-149
F1	Fuse, 1 1/4 amp	1	Littlefuse	312 1.25
	Fuseholder	1	"	348611
J33	Receptacle, Power Cord	1	Switchcraft	EAC-301
	Plate, Plexiglass High Voltage	1	Wilcom	0195-02-185
	Decal, High Voltage	2	Bovie	WP100
	Clamp, Capacitor	1	N. American	S1361-4
	Standoff, Teflon	1	Sealectro	013-2058-00-0-689
U4	IC, Voltage Regulator, 18V	1	Motorola	MC7818CP
	Socket, CRT (supplied with CRT)	1	Philips	55566
P31,32	Connector, 6 pin	2	Molex	09-50-3061
	Terminal, Female	12	"	08-50-0108
J26A,26B	Connector, 3 pin	2	"	03-06-2031
	Terminal, Male	5	"	02-06-2103
	Grommet	1	G.C. Elect.	1043C
S2	Switch, Slide (Line Voltage Select)	1	C.W. Ind.	GF-326-G-02-71-G-20-50

THUMBWHEEL ATTENUATOR SWITCH ASSEMBLY

Description		Qty	Mfr.	Manufacturer's Number
P.C. Board (Shield)		1	Wilcom	0195-02-154
Switch Assembly		1	"	0195-02-132
Resistor, $\pm 1\%$, 1/4W	21.5 ohm	1	TRW/IRC	T055
Resistor, " "	31.6 ohm	1	"	"
Resistor, " "	68.1 ohm	1	"	"
Resistor, " "	69.8 ohm	1	"	"
Resistor, " "	215 ohm	1	"	"
Resistor, " "	221 ohm	1	"	"
Resistor, " "	681 ohm	1	"	"
Resistor, " "	732 ohm	1	"	"
Resistor, " "	1.96k	4	"	"
Resistor, " "	2.15k	9	"	"
Resistor, " "	2.21k	4	"	"
Resistor, " "	2.32k	4	"	"
Resistor, " "	2.67k	1	"	"
Resistor, " "	6.81k	1	"	"
Resistor, " "	10.2k	1	"	"
Resistor, " "	17.8k	1	"	"
Resistor, " "	21.5k	1	"	"
Capacitor, 100V	.001 uF	1	F-Dyne	PC-11-.001-100-1
Capacitor, "	.002 uF	2	"	PC-11-.002-100-1
Capacitor, "	.004 uF	1	"	PC-11-.004-100-1
hookup wire, 22 gauge				
Ins Wire, 20 gauge				
Insulation, Teflon				

HIGH VOLTAGE HOUSING ASSEMBLY, Sheet Metal

Description	Qty	Mfr.	Manufacturer's Number
End Cage Support	1	Wilcom	0195-02-164
End Partition	1	"	0195-02-166
End Cage Partition	1	"	0195-02-167
End Plate	1	"	0195-02-168
Power Outlet Plate	1	"	0195-02-180
Housing, Bottom Section	1	"	0195-02-181
Housing, Top Section	1	"	0195-02-182

PRINTED CIRCUIT ASSEMBLY, POWER SUPPLY

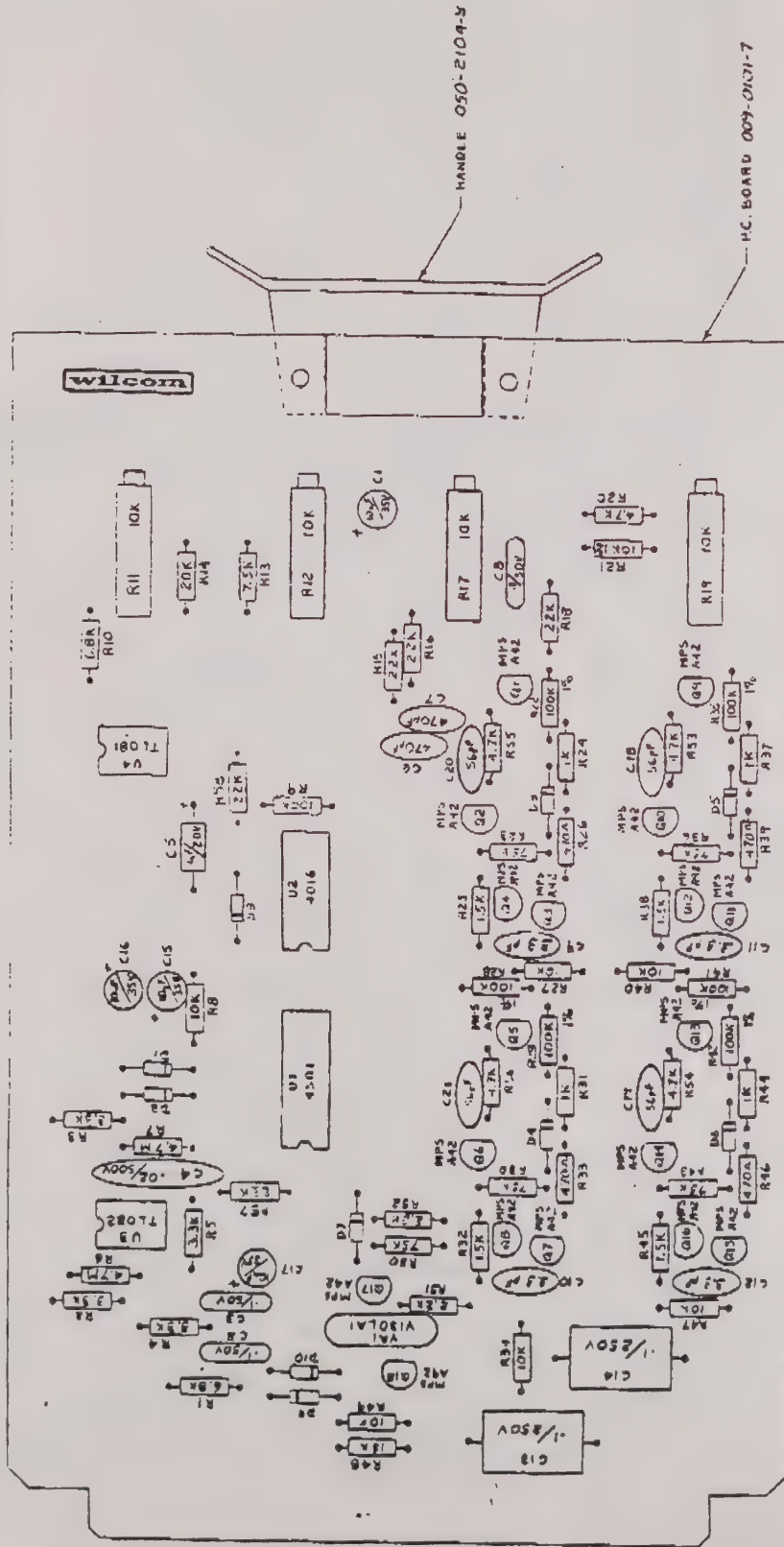
Ref. Desig.	Description		Qty	Mfr.	Manufacturer's Number
	P.C. BOARD		1	Wilcom	0195-02-186
R19,20,21	Resistor, $\pm 5\%$, 2W	3.6 meg	3	Allen Bradley	HB 364-5
R15	Resistor, " 1W	1.5 meg	1	" "	GB 154-5
R16,17	Resistor, " "	2.2 meg	2	" "	GB 224-5
R13	Resistor, $\pm 1\%$, 3/4W	100k	1	TRW/IRC	T060
R12	Resistor, " "	619k	1	" "	T060
R25,26	Resistor, " "	750k	2	" "	T060
R23,24	Resistor, $\pm 5\%$, 1/4W	15 ohm	2	" "	RG-1/4
R4,5	Resistor, " "	33 ohm	2	" "	"
R6,7	Resistor, " "	100 ohm	2	" "	"
R22	Resistor, $\pm 1\%$, 1/4W	39.2 ohm	1	" "	T055
R3	Resistor, " "	10k	1	" "	"
R1	Resistor, " "	7.5k	1	" "	"
R2,8-11	Resistor, " "	SEL	5	" "	"
R14	Potentiometer	1 meg	1	Allen Bradley	WA2G-056S-105MA
R18	Potentiometer	2 meg	1	" "	WA2G-056S-205MA
C5,6,8,13	Capacitor, Tant.	10 uF	4	ITT	TAG-A10M35
C7,29	Capacitor, Ceramic	.01 uF	2	Erie	811-000-Z5U0-103M
C19,20,23, 24	Capacitor,	.01 uF	4	Sprague	5GA-S10
C17,19,21, 22	Capacitor,	.02 uF	4	"	5GA-S20
C25,26		.005 uF	2	"	5GA-D50
C27,28,30	Capacitor, 3 kV	.01 uF	3	"	30GA-S10
C16	Capacitor, Elect. Tant.	180 uF	1	"	150D187X901052
C9-12	Capacitor, " "	100 uF	4	"	150D107X902052
C2	Capacitor, Alum. Elect.	68 uF	1	"	672D686H025CD5C
C4	Capacitor, Mono.	.1 uF	1	"	7CZ5U104X0050D
C3	Capacitor, Mylar.	.0033 uF	1	"	225P33291WD3
C14,15	Capacitor, Alum. Elect.	8 uF	2	"	TE-1406
VR1	Diode, Zener		1		1N5364A
CR1,2	Diode, Rectifier		2		1N4722
CR3	Diode, Silicon, Signal		1		1N4148
CR24,25	Diode, " Rectifier		2		1N4005
CR4,5,6,7, 12,13,22,23	Diode		8	Motorola	MR811
CR8-11	Diode		4	Motorola	MR812
CR14-21	Diode		8	Varo	VA15X
U1	IC		1	Motorola	MC7818CP
U3	IC		1	Sil. General	SG3501AD
U2	IC		1	Signetics	NE555
Q1,2	Transistor, PNP		2	G.E.	D41D4
Q4	Transistor, PNP		1	Motorola	MJE371
Q3	Transistor, NPN		1	Motorola	MJE521
L1,2	Inductor	100 uH	2	Cambion	553-3635-25
T2	Transformer, TECO 5893		1	Wilcom	0195-02-157
T3	Transformer, " 5908		1	"	0195-02-158
J1,25	Connector, 16 pin		2	Amp	350214-1
	Bracket		1	Wilcom	0195-02-139
J31,32	Plug, 6 pin		2	Molex	09-65-1061
	Standoff		1	Amatom	8221-B-0440
	Wire, #24 gauge				
	Insulating Sleeving, #22 gauge			Teflon	

10.0 DIFFERENCE DATA

10.1 General

10.1.01 This section of the manual indicates information relative to changes in circuitry, operation and features of the Model T195 Level Tracer.

1	REVISION	DATE	BY	CHKD	APP'D
0	REVISED HELMANN PER LEO 604	10-28	WJ		
1	ADDED C22, C23, C24, C25, C26	10-28	WJ		
2	REVISED PER LEO 604	10-28	WJ		
3	REVISED PER LEO 604	10-28	WJ		
4	REVISED PER LEO 604	10-28	WJ		
5	REVISED PER LEO 604	10-28	WJ		
6	REVISED PER LEO 604	10-28	WJ		
7	REVISED PER LEO 604	10-28	WJ		
8	REVISED PER LEO 604	10-28	WJ		
9	REVISED PER LEO 604	10-28	WJ		
10	REVISED PER LEO 604	10-28	WJ		



CAUTION
 CHANGES HAVE BEEN MADE
 ON THIS PAGE.
 SEE ISSUE SHEET 12/24/93

Newer Deflection
 Amplifier board Layout

FORMERLY DWG NO. 0195-02-007

Post-It brand fax transmittal memo 7671 # of pages 1

To: John Morton

From: minier

Co: GTE IN.

Co: Wilcom Repair

Dept:

Fax # 219-424-1031

Fax # 603 508-3804

4/1/91

D1-D6 = JH-1418
 D7 & D8 = JH-1405

T195	WILCOM	PRODUCTS INC.
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78
REV 2-2-78	REV 2-2-78	REV 2-2-78

PC ASSEMBLY
 DEFLECTION AMPLIFIER A4
 C 51778 200-0524-5

SEE ISSUE SHEET
ON THIS PAGE
CHANGES HAVE BEEN MADE
CAUTION

(PART OF CRT)

P36
HOUSING 052-0013-4
(5) CONTACTS 052-0216-3
(1) CONTACT 052-0088-6

NOTE - AFTER MAKING SOLDER CONNECTIONS GROUP WIRES AND TIE WITH CABLE TIE 050-0122-7

(2) DECALS 068-0081-7

DANGER
HIGH VOLTAGE

GROMMET 050-0050-0

APPLY SIL OVER PIN CONNECTOR ONTO CRT RED & YEL. W HT. SHRINK.

-EUC 44-1450-4
EW 16-0394-0

SOLDER LUG 050-1980-7
SCREW 046-0242-1
NUT 046-0058-1

(1) NUT 046-0119-1
(1) WASHER 046-0120-2

(1) SCREW 046-0205-3
(1) WASHER 046-0059-9

PLEXIGLASS 044-0314-3



PLANTRONICS
Wilcom

INSTRUCTIONS FOR RETROFITTING THE T195 LEVEL TRACER
WITH A NON-VOLATILE MEMORY

All T195's serial number 872 and above now incorporate a battery powered non-volatile memory. Measurements can be made in the field and stored in the memory by pressing the single update switch. The T195 then can be returned to the office and the trace can be re-displayed for further analysis. Conversely, a standard characteristic can be set up in a laboratory, stored and then the T195 can be taken into the field to compare actual cables against the standard. This is accomplished by the use of a ni-cad rechargeable battery on the Memory Circuit Board Assembly #200-0897-5. Either or both traces can be stored and will remain in the memory even if the set is not used for up to one month.

NOTE: Since the horizontal and vertical scaling information is not recorded in the memory, the settings of the Input and Sweep Controls should be recorded for reference when power is applied to the Level Tracer.

T195 Level Tracers Serial #871 and below are retrofitted as follows:

1. Refer to FIGURE 8-29 "Card Cage Assembly" page 831 and to FIGURE 6-2 "T195 Level Tracer Top View" page 6-6 of the T195 Instruction Manual (see Manual Change attached).
2. Remove Memory Circuit PC Board Assembly 0195-02-004.
3. Install Memory Circuit PC Board Assembly 200-0897-5.

A minor modification is required on Control Logic #2, PC Assembly 0195-02-012. Proceed as follows:

1. Remove Control Logic #2 (0195-02-012) Printed Circuit Board Assembly from unit (Refer to Section 6.7.03 step #6 of the T195 Instruction Manual Issue #1 also refer to FIGURE 6-2, page 6-6).
2. Using a small pair of cutting pliers, remove diodes CR4 and CR5. These are 1N4148 diodes. Cut diode leads as close as possible to Printed Circuit Board. See drawing FIGURE 8-5, page 8-6 "Control Logic #2" for location of the diodes.

continued

3. Re-install Control Logic #2 Printed Circuit Board in unit.

With the new Memory Circuit and modified Control Logic #2 Printed Circuit Board Assemblies installed in the unit a slight recalibration of the Vertical deflection amplifier may be required. The Vertical gain can be adjusted by referring to Section 7.7 of the T195 manual and following steps 1 - 4 and 8 - 11.

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P.O. BOX 508 LACONIA, N.H. 03246

MANUAL CHANGE INFORMATION

PRODUCT T195 Instruction
Manual, Issue 1ASSEMBLY Non-Volatile
Memory

CHANGE

DESCRIPTION

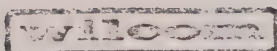
T195 Serial #
871 and belowInstructions for retrofitting the T195 Level Tracer with
a Non-Volatile Memory

DELETE:

Figure 6-2, page 6-6, "T195 Level Tracer Top View".
Delete the Card Cage Assembly numbers: 004
005
006
007
009

NOTE:

Refer to page 8-31, Figure 8-29, for the correct
location of the Card Cage PC Assemblies.



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MANUAL CHANGE INFORMATION

PRODUCT T195

ASSEMBLY

Memory Circuit

CHANGE

DESCRIPTION

ECO # 929 The Memory Circuit P.C. Assembly 0195-02-004 is replaced with
Serial # 872 Memory Circuit P.C. Assembly 20008795 to provide a non-
volatile memory. Additions and changes to the manual text
and drawings are as follows:

1.0 GENERAL

ADD 1.2.01 - a. A nonvolatile data storage system allows both traces
to be updated as required and will hold the stored
data, with power off, for use at some future time.

4.0 OPERATING INSTRUCTIONS

ADD 4.1.03 Memory Retention - The nonvolatile data storage system retains
the data in the memories when power is removed from the Level
Tracer. Both traces must be in the single update operating mode
(CONTINUOUS UPDATE buttons released) to retain the stored data when
power is applied to the Level Tracer.

NOTE: Since the horizontal and vertical scaling
information is not recorded in the memory, the
settings of the Input and Sweep Controls should
be recorded for reference when power is applied
to the Level Tracer.

5.0 CIRCUIT DESCRIPTION

REV Figure 5-6 New Memory Circuit

REV 5.3.07.09 As the successive READ ADDRESSES are presented to the
memories, the measurement data samples at those address
locations are read from the memories. The outputs of the memories
are selected by the DISPLAY TRACE 1 and DISPLAY TRACE 2 control
signals. The data information is latched and buffered before be-
ing presented to the vertical D/A converter.

REV 5.4.22.01 So, to clear memory, the data gate (U5/U6 on
board)....

REV 5.4.22.03 To prevent spurious readout of a memory that is being
both written and read in the same time slot during clear-
ing, the respective memory is output disabled and resistor network U19

T195 Memory Circuit (continued)

pulls the tri state outputs of the memory to ground. Thus, the data buffer (U11/U12) and the D/A converter (U13) see all memory data words as zeros while the memory is being cleared.

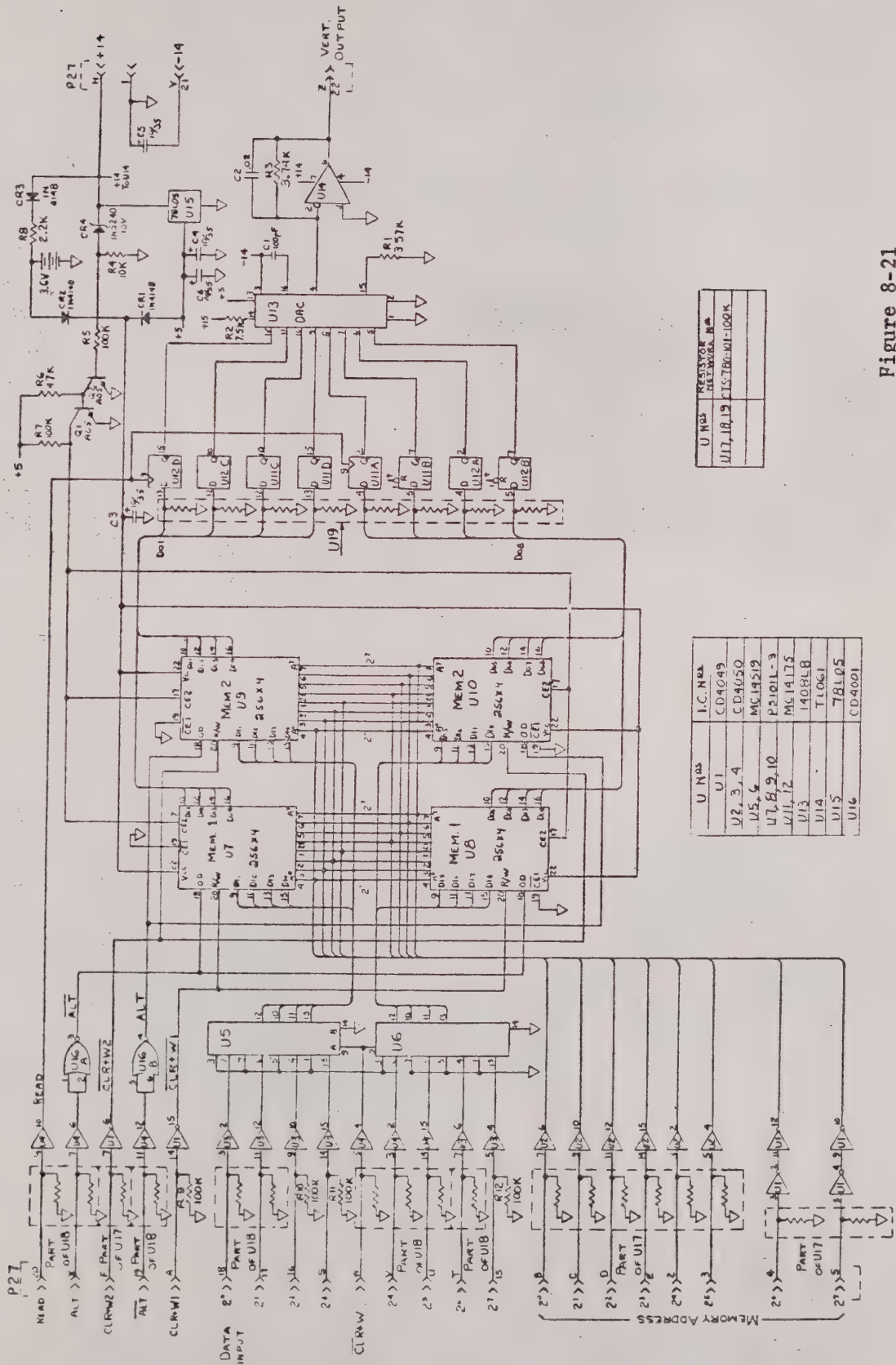
ADD 5.4.22.04 The nonvolatile data storage is provided by transistors Q1, Q2 and zener diode CR4 sensing the loss of +14V dc to the memory assembly and placing the memories in their standby mode. The storage mode Vcc for the memories is supplied by the 3.6V battery.

REV Figure 8-20, Memory Circuit Assembly: New Assembly (page 10-4)

REV Figure 8-21, Memory Circuit Schematic: New Schematic (page 10-5)

REV PARTS LIST Memory P.C. Assembly: New Assembly (see below)

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
	P.C. BOARD	1	Wilcom	00903740
R1	Resistor, 1/4W, 1% 3.57K	1	TRW/IRC	TO55
R3	Resistor, 1/4W, 1% 3.74K	1	"	"
R2	Resistor, " " 7.50K	1	"	"
R8	Resistor, 1/4W, 5% 2.2K	1	"	RG-1/4
R4	Resistor, " " 10K	1	"	"
R6	Resistor, " " 47K	1	"	"
R5,7,9, 10,11,12	Resistor, " " 100K	6	"	"
C1	Capacitor, Ceramic Disc. 10% 100pF	1	Sprague	851-000-V2J0101J
C2	Capacitor, " " .02uF	1	Sprague	5GAS-S20
C3,4,5,6	Capacitor, Tant. 20%, 35V 10uF	4	ITT	TAG-100-10/35-10
CR1,2,3	Diode, Small Signal	3		1N4148
CR4	Diode, Zener	1	Motorola	1N5240
Q1,2	Transistor	2	Motorola	MPSA05
U16	Int. Circuit, Quad 2-Input Nor Gate	1	RCA	CD4001BE
U1	Int. Circuit, Inverter	1	RCA	CD4049BE
U2,3,4	Int. Circuit, Buffer	3	RCA	CD4050BE
U5,6	Int. Circuit, Data Selector	2	Motorola	MC14519BP
U7,8,9,10	Int. Circuit, 256x4 Memory (SCM5101E3)	4	INTEL	5101L-3(00700777)
U11,12	Int. Circuit, Quad D Flip Flop	2	Motorola	MC14175BCP
U13	Int. Circuit, D/A Converter	1	Motorola	MC1408L8
U14	Int. Circuit, OP-AMP	1	TI	TL061CP
U15	Int. Circuit, 5V Regulator	1	Fairchild	ua 78L05AWC
U17,18,19	Resistor Network	3	CTS	750-101-R100K
BT-1	Battery, NICAD 3.6V	1	GE	DS35D
	Socket, I.C. 22 Pin	4	TI	C9322-02



U No	IC No
U1, U2, U3, U4, U5, U6, U7, U8, U9, U10, U11, U12, U13, U14, U15, U16	7409, 7404, 7401, 7402

U No	IC No
U1	CD4049
U2, U3, U4	CD4050
U5, U6	MC14219
U7, U8, U9, U10	P2101L-3
U11, U12	MC14175
U13	1408LB
U14	TL061
U15	78L05
U16	CD4001

Figure 8-21
Memory Circuit Schematic

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MANUAL CHANGE INFORMATION

PRODUCT T195

ASSEMBLY (A7)

Control Logic #2

CHANGE

DESCRIPTION

ECO # 961 The Control Logic #2 P.C. Assembly 0195-02-012 is replaced
Serial # 872 with Control Logic #2 P.C. Assembly 20009825 in order to
 be compatible with the new Memory P.C. Assembly.
 Additions and changes to the manual are as follows:

REV Figure 8-5 Control Logic Assembly (012): delete CR4, 5 (Page 8-6)

REV Figure 8-6 Control Logic Schematic: delete CR4, 5 (Page 8-7)

REV Parts List Control Logic #2 P.C. Assembly: delete CR4,5 (Page 9-4)

PRODUCT T195
Level Tracer

ASSEMBLY Preamp
and Display Scaling

CHANGE

DESCRIPTION

ECO #971 Diode, CR2, added to feedback circuit of U14 to limit
Serial #852 negative voltage excursion.

REV Parts List - Preamplifier and Display Scaling Printed Circuit Assembly

Ref. Desig.	Description	Qty	Mfr.	Manufacturer's Number
CR2	Diode	1		1N4148

REV Figure 8-9 Preamp and Display Scaling Assembly (015) - add CR2

REV Figure 8-10 Preamp and Display Scaling Assembly Schematic - add CR2

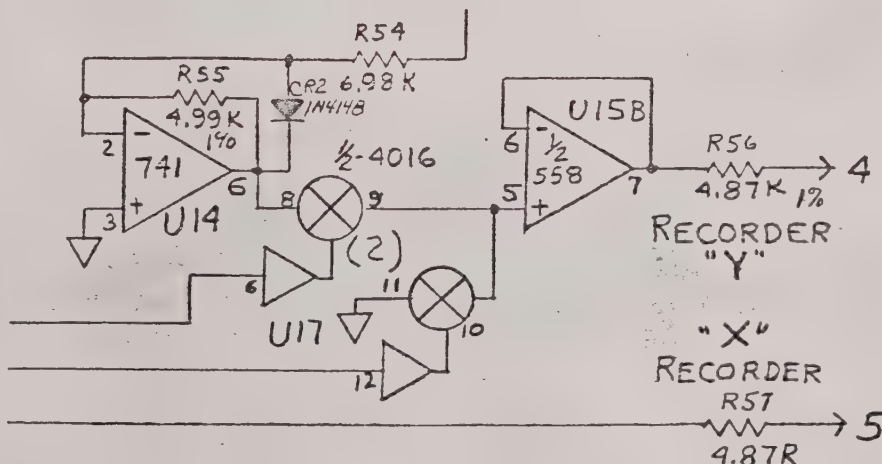
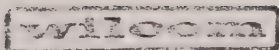


Figure 8-10
Preamp and Display Scaling Schematic.



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MANUAL CHANGE INFORMATION

PRODUCT T195 Instruction
Manual, Issue 1

ASSEMBLY Page 6-6
Figure 6-2

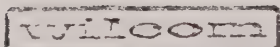
CHANGE

DESCRIPTION

ECO #1109

DELETE: Figure 6-2, page 6-6, "T195 Level Tracer Top View".
Delete the Card Cage Assembly numbers: 004
005
006
007
009

Refer to page 8-31, Figure 8-29, for the correct
location of the Card Cage PC Assemblies.



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MANUAL CHANGE INFORMATION

PRODUCT T195

ASSEMBLY Alignment
and Calibration

CHANGE

DESCRIPTION

ECO # 1204 4.0 OPERATING INSTRUCTIONS

Serial No. All 4.2 Initial Conditions

4.2.01 During initial familiarization etc.....

1. Set all controls as follows:

DELETE:	IMPEDANCE COMPENSATOR: D66 &	REF Released
ADD:	IMPEDANCE COMPENSATOR: D66 & H88	Released
DELETE:	H88 FUNCTION: LEVEL	ENGAGED
ADD:	FUNCTION: LEVEL	ENGAGED

4.10 Return loss measurements (RET LOSS)

4.10.04 The reference against which etc.....

DELETE: on line #4 the word: INTERNAL and replace it with the word EXTERNAL.

7.0 ALIGNMENT AND CALIBRATION

REV: Section 7.7 Deflection Amplifier
Section 7.8 Tracking Analog Digital Converter
Section 7.9 Sweep Generator (7.9.01)

NOTE: The above sections (7.7, 7.8 and 7.9) have been rearranged and revised as follows:

7.7 Tracking Analog Digital Converter

7.7.01 All adjustments in this section are located on the Analog to Digital Converter Assembly (006) located in the card cage assembly.

1. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1. (8KHz)
2. Tuning switch to MAN
3. Frequency range 4 k
4. Manual tuning pot to minimum (counterclockwise)
5. Adjust front panel "O-CAL" to read zero Hz⁺2 on frequency display.
6. Increase the MANUAL TUNING knob while visually observing the marker across the CRT and stop at exactly the time the marker physically reaches the end of the trace. Read the frequency display at 4000⁺ 10 Hz.

7. If not at 4000 ± 10 Hz, then adjust the pot R41 on the A/D board (006).

8. Between approximately 3992 Hz and 4008 Hz the analog to digital converter will product the same digital value. For this reason, the MANUAL TUNING knob should be "rocked" back and forth to verify the actual end of the trace.

7.8 Deflection Amplifier

7.8.01 All adjustments in this section are located on the Deflection Amplifier Assembly (007) located in the card cage assembly.

1. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1.
2. Press to engage the POWER pushbutton.
3. Install patch cord between LINE 1 and SEND terminals.
4. Adjust the INTENSITY, FOCUS and ASTIG knobs for a well defined trace along the zero dB reference line. The input relay switching between traces should be audible.
5. Calibrate the HOR POS as follows:
 - a. Engage the TUNING: MAN pushbutton and turn the MANUAL TUNING knob fully counterclockwise.
 - b. Adjust the screwdriver O-CAL control for zero SEND FREQUENCY
 - c. Adjust the MANUAL TUNING knob for a SEND FREQUENCY of 4000 Hz.
 - d. Adjust the HOR POS knob to center the frequency marker.
6. Adjust horizontal gain pot R19 to align end of CRT trace behind righthand vertical line of graticule.
7. Adjust marker amplitude pot R17 for a frequency marker height equal to one CRT graticule division.
8. Remove patch cord: Engage TUNING: SW and FUNCTION: IMP pushbutton.
9. Press Trace 2 SINGLE UPDATE: after completion of sweep press Trace 2 CLEAR.
10. Adjust vertical position reference pot R11 to align bottom trace 2 behind -30 dB graticule line.
11. Adjust vertical gain pot R12 to align top trace 1 behind +10 dB graticule line.
12. Rotate the HOR POS control to check for a trace movement of about one-half inch in both directions and recenter the control.

7.9 Sweep Generator

7.9.01 All adjustments in this section are located on the Sweep Oscillator Assembly (074) located behind the FREQ RANGE and TUNING pushbutton.

1. Set all front panel switches in accordance with initial conditions of Section 4.2.01, Step 1.

2. Press to engage the MAN TUNING pushbutton.
3. Press to engage the 400 Hz FREQ RANGE pushbutton.
4. Turn front panel manual tuning pot to minimum.
 - 4a. Press each frequency range push button and observe no more than 30 Hz deviation. If deviation is within limits, proceed to step 11, if not continue with step 5.
5. Adjust R43 for zero on frequency display readout.

CAUTION

Do not adjust temperature compensating control R41

6. Monitor TP2 and adjust R59 for 0 $\pm$ 100 mV dc offset. Repeat steps 5 & 6 until both conditions are satisfied.
7. Turn the O-CAL pot clockwise until it clicks. (FREQ stops changing)
8. Adjust R43 for 135 Hz on frequency display readout.
9. Adjust O-CAL pot for 0 Hz on frequency display readout.
10. Depress each frequency range push button and observe no more than 30 Hz deviation. Note: Pot has an adjustment range of approximately 280 Hz.
11. Connect an accurate level meter providing a 600 ohm termination to the send terminals. Engage FREQ RANGE Hz, 4 k pushbutton and set SEND FREQUENCY to 2000 Hz.
12. Adjust level meter for an on scale reading (approximately 0 dB).

Continue with line 13, Section 7.9.01 page 7-3

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MANUAL CHANGE INFORMATION

PRODUCT T195

ASSEMBLY Alignment

(continued)

and calibration

CHANGE

DESCRIPTION

REV: 7.10 Measurement Circuit

7.10.03

2. Linearity

- a. Monitor TP2 and adjust the oscillator level to check linearity.

AC voltmeter reading

TP2 voltage

DELETE: 1.549 V +10 1.000 V dc $\pm$.015 V dcADD: 1.549 V +00 1.000 V dc $\pm$.015 V dc

REV: 7.11 Preamp and Display Sealing

7.11.02

Item #12. Revise to read:

Increase the test oscillator level to 1.0 dB and observe approximately -7.0 V dc at TP3. The CRT trace appears at the +1 graticule.

